
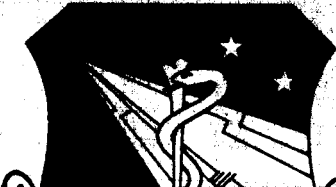


BIOCHEMICAL AND PHYSIOLOGICAL EVALUATION OF HUMAN SUBJECTS IN A LIFE SUPPORT SYSTEMS EVALUATOR

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FOREWORD

This research was initiated by the Aerospace Medical Research Laboratories , Wright-Patterson Air Force Base, Ohio, and was accomplished by the Department of Research of the Miami Valley Hospital, Dayton, Ohio, and the Biotechnology Branch, Life Support Division, Biomedical Laboratory, Aerospace Medical Research Laboratories. This effort was supported jointly by the USAF under Project No. 7164, "Biomedical Criteria for Aerospace Flight," Task No. 716405, "Aerospace Nutrition," and NASA Manned Spacecraft Center, Houston, Texas, under Contract R-85, "The Protein, Water, and Energy Requirements of Man Under Simulated Aerospace Conditions." This contract was initiated by 1st Lt John E. Vanderveen, monitored by 1st Lt Keith J. Smith, and completed by Alton E. Prince, PhD, for the USAF. Technical contract monitor for NASA was Paul A. Lachance, PhD. The research effort of the Department of Research, Miami Valley Hospital, was accomplished under Contract AF 33 (657)-11716. Bernard J. Katchman, PhD, and George M. Homer, PhD, were technical contract administrators, and Robert E. Zipf, MD, Director of Research, had overall contractual responsibility.

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This technical report has been reviewed and is approved.

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Technical Director
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ABSTRACT

A 6-week study with four college students as volunteer subjects was conducted for the purpose of evaluating the nutritional requirements of individuals undergoing stresses imposed by simulated aerospace conditions. A 4-day cycle diet of fresh foods was served at room temperature each day; it was comprised of 110 g of protein, 315 g of carbohydrate, 80 g of fat, and 2621 calories. All the clinical data were in the normal range and no significant differences were observed between control and confinement in the Life Support Systems Evaluator. Metabolic balances show excellent adjustment to the diet; all subjects were in positive nitrogen balance. Physiological measurements of heart rate, blood pressure, and oral temperature were in the normal ranges. Minimal body weight changes were observed indicating that the diet was adequate. The diet was only moderately acceptable because all food was served at room temperature; gravy and cream sauces were rated least acceptable for this reason.

Author

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SECTION I

INTRODUCTION

A series of studies have been designed to establish water, energy, and protein requirements of man under simulated aerospace conditions. Previous studies (1,2) were concerned with the effects of a 6-week confinement in a controlled activity facility (CAF),* and wearing an unpressurized MA-10 pressure suit** continuously for 14 days while the subjects ate either a diet composed of fresh foods or an experimental diet composed of freeze dehydrated foods. The results showed no significant changes in the water, energy, and protein requirements of man while in confinement or wearing the MA-10 pressure suit, either on the fresh foods diet or the experimental diet. Normal health was maintained throughout these experiments and food acceptability was high and did not decrease significantly over the 6-week experimental period.

This study is a continuation of the above studies with the evaluation of the water, energy, and protein requirements of four subjects confined in the Life Support Systems Evaluator (LSSE)* for a period of 4 weeks during which time the subjects ate a diet composed of fresh foods.

The initial phase of this study consisted of a 1-week confinement and orientation period in the CAF. A 4-week confinement in the LSSE followed wherein the subjects participated in activities of simulated space travel, collection of biological samples, and in recording requisite physiological measurements. A final week of confinement and debriefing in the CAF completed this study. Specific evaluations of energy, nitrogen, fat, crude fiber, and electrolyte requirements in respect to balance and digestibility were undertaken. The general health of the subjects was followed during the various phases of the study. In addition to an evaluation of the physiological adequacy of the dietary regimen, an organoleptic acceptability rating of the diet was carried out by the subjects.

* The controlled activity facility (CAF) and the Life Support Systems Evaluator (LSSE) at the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, were used to provide a simulated space cabin environment.

** The MA-10 pressure suits were furnished for these experiments by the Manned Spacecraft Center, NASA, Houston, Texas.

SECTION II

METHODS

Four human male subjects were confined either in the CAF or the LSSE for a period of 6 weeks. Each of the subjects was selected upon the basis of physical, psychiatric, and microbiological examinations. The physical characteristics of the test subjects are listed in table I.

The major change in design for this experiment, relative to the other experiments in this series, involved the use of the LSSE during the middle 4 weeks of the 6-week study; the subjects were confined in the CAF during the first and sixth weeks of the experiment. The experimental design and daily activity schedule followed during the experiment are presented in tables II and III, respectively. The protocol for the CAF and LSSE was such that additional stress of confinement was imposed by the LSSE. Only a limited number of personnel were permitted to enter the CAF during the first and sixth weeks. Communications were conducted by two-way telephone in the CAF, and by telephone and television while in the LSSE. The subjects were monitored 24 hours a day and were examined daily by a physician while in the CAF and were interviewed by a physician each day while in the LSSE.

Every effort was made to eliminate the accidental introduction of contaminating microorganisms into the subjects' living areas. Those persons entering the CAF were always required to scrub and don sterile cap, gown, gloves, and shoe coverings. Subjects were thoroughly showered and scrubbed with a bactericide followed by a rinse with 70% alcohol prior to donning sterile clothing and entering either the CAF or the LSSE. During the entire study, swabs were made of specific body areas, environmental areas, and fecal samples for the purpose of evaluating the microbiological flora existing under the prevailing experimental conditions. The results will be reported separately.

No shaving, haircuts or hair grooming, or clipping of nails were permitted during the experiment. Oral hygiene was limited to the use of an electric toothbrush and gum stimulator the first week, and the gum stimulator only during the remaining 5 weeks of the study.

Requisite chemical analyses were accomplished as follows: food - moisture (3), nitrogen (4), fat (5) crude fiber (6), ash (7), sodium and potassium (8), chloride (9), calcium and magnesium (10), phosphorus (11), calorimetry (12), and carbohydrate determined by difference; blood - red blood cell count, white blood cell count, differential count, morphology, total eosinophil count, and hematocrit (13), hemoglobin (14), glucose (15), creatinine (16), calcium (17), chloride (18), phosphorus (19), and sodium and potassium (20); urine - daily volume, moisture, and total solids content (21),

specific gravity (22), pH (23), qualitative protein (24), microscopic examination, nitrogen (4), sodium and potassium (8), chloride (9), calcium and magnesium (10), phosphorus (11), and calorimetry (12); feces - moisture (3), nitrogen (4), fat (5), crude fiber (6), ash (7), sodium and potassium (8), chloride (9), calcium and magnesium (10), calorimetry (12), and occult blood on selected samples only.

Sample collections were made as designated in table II. Food samples were collected during the first, third, and fifth weeks of the experiment and analyzed. Fasting venous blood samples were drawn for hematology and chemical analyses. Urine samples were collected daily and the requisite analyses made prior to dilution of the 24-hour volume to 2 liters and combination of 4-day aliquots for further analyses. Feces samples were frozen as received and combined into 4-day samples before analysis.

The total fecal and urinary excretion and the mean daily excretion of the various elements analyzed were determined for each experimental period. This data plus the food analyses were utilized for the calculation of nutrient digestibilities and balances. The balances were computed by subtracting the total output of a given constituent excreted in the urine and feces from the total dietary intake of that constituent. The coefficients of apparent digestibility were calculated by subtracting the fecal excretion from the dietary intake and determining the percent of total intake absorbed or utilized.

TABLE I
PHYSICAL CHARACTERISTICS OF TEST SUBJECTS

Subject No.	Age	Weight		Height	
		kg	lb	cm	in
17	23	76.4	168	175	69
18	22	70.4	155	170	67
19	22	68.2	150	178	70
20	23	72.8	160	170	67

TABLE II
EXPERIMENTAL DESIGN

Experimental day	Condition (period)	Metabolic diet*	Blood collection**	Urine†	Feces†
1	Pre-Chamber 7 days	2] U 1	
2		3			
3		4	X		
4		1			
5	Chamber 28 days	2] U 2] F 1
6		3			
7		4	X		
8		1			
9		2] U 3] F 2
10		3			
11		4			
12		1			
13		2] U 4] F 3
14		3			
15		4	X		
16		1			
17		2] U 5] F 4
18		3			
19		4			
20		1			
21		2] U 6] F 5
22		3			
23		4	X		
24		1			
25		2] U 7] F 6
26		3			
27		4			
28		1			
29		2] U 8] F 7
30		3			
31		4	X		
32		1			
33		2] U 9] F 8
34		3			
35		4			
36	Post-Chamber 7 days	1			
37		2] U 10] F 9
38		3			
39		4	X		
40		1			
41		2] U 11	
42		3			
43			X		

* Metabolic diet was a fresh prepared, four cycle diet served at room temperature.

** Venous blood samples drawn for hematological and chemical analyses.

† Individual urine or feces samples combined and numbered as indicated for analysis.

TABLE III
DAILY ACTIVITY SCHEDULE

Time	Subject No.		Subject No.		Time
	17	19	18	20	
0800	Wake; void; physiological measurements. Transfer food and other items into chamber. Biological specimens collected and returned to laboratory				0800
0900	Eat meal A. Transfer materials from chamber				0900
1000	Free time				1000
1100	Psychological testing 17 Exercise 19		Sleep		1100
1200					1200
1300					1300
1400					1400
1500	Psychological testing 19 Exercise 17				1500
1600					1600
1700	Free time				1700
1800	Eat meal C				1800
1900	Free time and exercise				1900
2000					2000
2100	Eat meal D		Eat meal B		2100
2200					2200
2300	Free time				2300
2400					2400
0100	Sleep		Eat meal C		0100
0200			Free time		0200
0300			Psychological testing 18		0300
0400			Exercise 20		0400
0500			Eat meal D		0500
0600			Psychological testing 20		0600
0700			Exercise 18		0700
0800					0800

Physiological measurements were as follows: water intake, oral temperature, body weight, blood pressure, and heart rate. Heart rate measurements were made at the same time (0800) on all subjects under conditions of normal rest. Additional heart rate measurements were made on all subjects at different times while undergoing the following specified exercise procedure: rest 10 minutes, measure heart rate; exercise 10 minutes on an ergometer, measure heart rate; and rest 10 minutes, measure heart rate. The work load chosen for the subjects on the ergometer was established to require an approximate expenditure of 300 kcal per hour.

The metabolic diet consisted of a 4-day cycle menu of fresh foods served at room temperature. The compositions of the metabolic diets are presented in tables IV through VII where the calculated values, determined from tables of average portions presented in Bowes and Church (25), are as follows: 300 g carbohydrate, 104 g protein, 86 g fat, and 2500 kcal per day. In addition to adjusting the diet composition so that daily food intakes were comparable (carbohydrate, protein, fat, and calories), the four daily meals were similarly adjusted within each day's diet and for the same meal served on separate days. The actual analyses of the metabolic diets are presented in table VIII.

The majority of food items were purchased in advance and an effort was made to acquire specific items in the same brand and lot number for the entire study period. In addition to fresh foods (milk, eggs, etc.) which were purchased at intervals during the experiment, other non-fresh foods were also purchased on occasions which may be expected to contribute to variations in food analysis data relative to expected theoretical values.

All food items were prepared within a 24-hour period prior to serving according to instructions established by the dietitian. All items were prepared with distilled water. Individual portions for each meal were weighed on a Mettler balance to the nearest gram in pre-weighed and treated paper containers. The containers were labeled with the date and the appropriate subject, diet, and meal number, and stored in a refrigerator. A complete day's supply of food for the four subjects was transferred to either the CAF or the LSSE between 0800 and 0900 daily. The subjects were instructed to retain all food in the refrigerator; each meal was removed one-half hour prior to the scheduled meal hour so that the food was consumed at room temperature.

The subjects were instructed on the importance of consuming all food provided at each meal. Instructions were also given for the procedure to be followed in the event illness occurred which necessitated food weigh-backs.

The method of food evaluation in terms of a nine-point acceptability scale used in previous experiments was followed for this study. The form shown in table IX was presented to each subject at each meal with the requirement that all food items be rated according to the given scale of acceptability. Additional comments regarding food preparations, food combinations, monotony, etc., were encouraged.

TABLE IV
METABOLIC DIET 1

	Weight g	Carbohydrate g	Protein g	Fat g
<u>Meal A</u>				
Grapefruit juice	185	20.50	0.90	0.20
Sugar frosted flakes	25	22.38	1.13	0.04
Half & Half	30	1.30	0.90	3.00
Beef and vegetables	80	2.42	18.92	4.32
Toast	12	6.30	1.04	0.37
Butter	8	0.00	0.00	6.40
Banana cube	23	13.44	2.52	5.64
Apricots	72	12.84	0.36	0.06
		<u>79.18</u>	<u>25.77</u>	<u>20.03</u>
<u>Meal B</u>				
Corn chowder	201	37.38	5.59	4.78
Peanut butter sandwich	38	13.13	6.70	10.13
Beef	40	0.00	11.74	2.68
Potato	80	15.28	1.60	0.08
Butter	3	0.00	0.00	2.40
Pound cake	20	13.83	0.78	4.50
		<u>79.62</u>	<u>26.41</u>	<u>24.57</u>
<u>Meal C</u>				
Chicken sandwich	37	9.06	6.25	0.34
Canadian bacon	28	3.82	7.90	5.35
Toast	39	20.10	3.38	1.18
Butter	5	0.00	0.00	4.00
Chocolate pudding	267	48.00	7.25	10.56
		<u>80.98</u>	<u>24.78</u>	<u>21.43</u>
<u>Meal D</u>				
Roast beef	67	0.00	19.51	4.46
Toast	37	19.00	3.20	1.12
Butter	15	0.00	0.00	12.00
Pineapple cake	92	40.30	3.78	5.64
Fruit cocktail	90	16.75	0.23	0.31
Tea and sugar	186	7.70	0.40	0.00
		<u>83.75</u>	<u>27.12</u>	<u>23.53</u>
Daily total		323.53	104.08	89.56
Total calories	2517			

TABLE V
METABOLIC DIET 2

	Weight	Carbohydrate	Protein	Fat
	g	g	g	g
<u>Meal A</u>				
Orange-grapefruit juice	176	18.68	1.05	0.08
Sugar frosted flakes	20	17.90	0.90	0.03
Skimmed milk	120	5.60	3.96	0.10
Fried chicken leg	45	1.69	11.80	5.96
Cheese sandwich	34	6.50	6.68	7.43
Brownies	39	21.66	1.71	7.79
Tea and sugar	186	7.70	0.40	0.00
		<u>79.73</u>	<u>26.50</u>	<u>21.39</u>
<u>Meal B</u>				
Beef and gravy	106	10.38	16.45	6.62
Potato salad	72	10.91	5.66	12.95
Cinnamon toast	22	9.30	1.04	3.57
Apricots	150	26.75	0.75	0.13
Vanilla pudding	86	25.20	2.03	0.05
		<u>82.54</u>	<u>25.93</u>	<u>23.32</u>
<u>Meal C</u>				
Orange juice	172	18.80	1.30	Trace
Tuna salad	85	3.40	19.10	10.83
Mushroom soup	297	11.40	3.45	11.55
Toast	12	6.30	1.04	0.37
Applesauce	210	43.75	0.35	0.53
		<u>83.65</u>	<u>25.24</u>	<u>23.28</u>
<u>Meal D</u>				
All Star cereal	25	22.38	1.30	0.05
Skimmed milk	60	2.80	1.98	0.18
Beef sandwich	37	3.02	9.59	2.15
Creamed carrots	108	7.90	1.80	4.50
Toast	37	19.00	3.20	1.12
Butter	6	0.00	0.00	4.80
Cocoa	188	30.70	5.24	5.09
		<u>85.80</u>	<u>23.11</u>	<u>17.89</u>
Daily total		331.72	100.78	85.88
Total calories	2503			

TABLE VI
METABOLIC DIET 3

	Weight	Carbohydrate	Protein	Fat
	g	g	g	g
<u>Meal A</u>				
Grape juice	100	18.28	0.39	Trace
Sugar frosted flakes	10	8.95	0.45	0.02
Skimmed milk	30	1.40	0.99	0.03
Toast	12	6.30	1.04	0.37
Butter	5	0.00	0.00	4.00
Salmon salad	141	6.00	20.49	19.38
Fruit compote	153	32.25	0.73	0.18
Tea and sugar	186	7.70	0.40	0.00
		<u>80.88</u>	<u>24.49</u>	<u>23.98</u>
<u>Meal B</u>				
Orange-pineapple juice	183	21.96	0.99	0.08
Spaghetti and meat	95	5.65	10.00	9.52
Beef sandwich	45	3.02	9.59	8.55
Date cake	84	46.54	3.68	7.58
		<u>77.17</u>	<u>24.26</u>	<u>25.73</u>
<u>Meal C</u>				
Grapefruit juice	185	20.50	0.90	0.20
Hard cooked egg	54	0.30	6.90	5.50
Broiled bacon	7	0.20	1.80	4.40
Chicken and vegetables	94	3.78	15.65	0.45
Butterscotch pudding	164	55.40	4.30	9.50
		<u>80.18</u>	<u>29.55</u>	<u>20.05</u>
<u>Meal D</u>				
Potato soup	251	28.67	4.45	6.40
Canned shrimp	60	0.00	16.00	0.80
Pineapple cubes	35	20.90	4.10	8.40
Gingerbread	50	34.88	2.44	4.12
		<u>84.45</u>	<u>26.99</u>	<u>19.72</u>
Daily total		322.68	105.29	89.48
Total calories	2517			

TABLE VII
METABOLIC DIET 4

	Weight	Carbohydrate	Protein	Fat
	g	g	g	g
<u>Meal A</u>				
Grape juice	140	25.59	0.54	Trace
Sausage	70	2.35	19.83	17.11
Toast	39	20.10	3.38	1.18
Cocoa	188	30.70	5.24	5.09
		<u>78.74</u>	<u>28.99</u>	<u>23.38</u>
<u>Meal B</u>				
Chicken salad	119	2.87	22.57	14.72
Creamed green beans	143	7.70	2.40	4.20
Banana pudding	220	57.90	4.66	1.80
Tea and sugar	186	7.70	0.40	0.00
		<u>76.17</u>	<u>30.03</u>	<u>20.72</u>
<u>Meal C</u>				
Blended juice (apple-pineapple)	390	51.00	0.85	0.22
Ham and applesauce	58	10.07	7.95	3.07
Peanut butter sandwich	38	13.13	6.70	10.13
Potato salad	72	10.91	5.66	12.95
		<u>85.11</u>	<u>21.16</u>	<u>26.37</u>
<u>Meal D</u>				
Grape juice	140	25.59	0.54	Trace
Pea soup	192	23.25	6.30	4.03
Chicken and gravy	203	13.83	15.78	14.00
Apricots	105	18.70	0.52	0.09
		<u>81.37</u>	<u>23.14</u>	<u>18.12</u>
Daily total		321.39	103.32	88.59
Total calories	2496			

TABLE VIII
ANALYSES OF METABOLIC DIETS

Constituent*	Units	Metabolic diet			
		1	2	3	4
Sample weight	g	1707.1	2274.6	1980.2	2195.6
Moisture	%	69.2	75.2	73.9	76.7
Nitrogen	g	18.18	17.24	17.08	17.69
Protein	g	113.7	107.8	106.8	110.6
	%	21.6	19.1	20.6	21.6
Fat	g	74.6	92.0	68.5	85.4
	%	14.2	16.3	13.2	16.7
Cellulose	g	6.4	7.4	6.7	9.0
	%	1.2	1.3	1.3	1.8
Ash	g	15.2	20.5	18.9	18.7
	%	2.9	3.6	3.7	3.6
Carbohydrate**	g	317.2	337.6	316.7	289.0
	%	60.2	59.7	61.2	56.4
Calcium	g	0.59	0.91	1.07	0.52
Phosphorus	g	1.31	1.38	1.45	1.35
Sodium	g	3.2	4.5	3.7	4.0
Potassium	g	2.7	3.2	3.0	2.9
Magnesium	g	0.29	0.28	0.25	0.33
Chloride†	g	8.54	12.25	10.14	11.38
Energy	kcal	2601	2832	2502	2548

Analyses provided by Wisconsin Alumni Research Foundation, Madison, Wis.

* Percent values, other than moisture, are presented as percent constituent of the dried sample.

** Carbohydrate calculated by difference.

† Chloride expressed as sodium chloride.

TABLE IX

MEAL EVALUATION FORM

Fresh diet

Diet _____ Meal _____

Name _____ Date _____

Rate each item with the number that best indicates your taste .

- 9 - Like Extremely
- 8 - Like Very Much
- 7 - Like Moderately
- 6 - Like Slightly
- 5 - Neither Like nor Dislike
- 4 - Dislike Slightly
- 3 - Dislike Moderately
- 2 - Dislike Very Much
- 1 - Dislike Extremely

FOOD

SCORE

Do Not Mark In
These Spaces

Orange-grapefruit juice	
Sugar frosted flakes	
Fried chicken	
Cheese sandwich	
Brownies	
Tea and sugar	

Additional Comments:

SECTION III

RESULTS

The results of chemical analyses on the metabolic diets are presented in table VIII. Carbohydrate values were determined by adding the moisture, protein, fat, crude fiber, and ash content of the specific food sample and subtracting this total from the original weight of the sample.

The average protein, carbohydrate, and fat contents of the four metabolic diets, as presented in table VIII, are 109.7 g, 315.1 g, and 80.1 g, respectively. These values are approximately 6% higher in protein, 3% lower in carbohydrate, and 9% lower in fat content than the theoretical values computed (tables IV-VII).

Energy values (table X) determined by bomb calorimetry measurements on the food samples are similar to the theoretical energy values for protein, carbohydrate, and fat (tables IV-VII) obtained by using the accepted combustion values of 4.3, 4.0, and 9.5, respectively (26). An average calculated caloric value is 2583 kcal which differs from the average caloric value of 2621, determined by bomb calorimetry, by only 1.5%. When energy is calculated by using the accepted combustion values, as above, and the analyzed values for protein, carbohydrate, and fat, an average caloric value of 2493 is obtained which is approximately 5% lower than the value determined by bomb calorimetry. The major difference (128 kcal) between the caloric content by bomb calorimetry and by calculation from the analyzed diet may be ascribed to the lower fat content found for the analyzed diet. The average value of 80.1 g of fat for the analyzed diet is 8.3 g less than the average value ascribed to the diet according to the theoretical values and constitutes approximately 62% of the caloric difference.

When the theoretical values for protein, carbohydrate, and fat (tables IV-VII) are multiplied by the accepted combustion values of 4.0, 4.0, and 9.0, respectively (26) for the purpose of determining energy available from ingested food, an average value of 2508 kcal is calculated. These combustion values take into consideration energy losses due to incomplete assimilation of ingested food. This value compares favorably with the average digestible caloric value of 2525 kcal for all subjects (table X).

All the data on energy utilization are presented in table X. Digestible energy is intake energy minus undigested energy (in feces), and this represents the energy actually utilized. A high degree of absorption of available energy was found; the combined subject average was 96.3%, coefficient of apparent digestibility. Of the 2525 kcal of digestible energy, 2411 kcal were metabolized, indicating a high degree (95%) of energy utilized.

TABLE X
ENERGY BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake cal	Undigested in feces cal	Digestible cal	Excreted in urine cal	Metabo- lizable cal	Coefficient of apparent digestibility %
Pre-Chamber	17	2621	67	2554	116	2438	97.4
	18	2621	97	2524	88	2436	96.3
	19	2621	69	2552	116	2436	97.4
	20	2621	80	2541	110	2431	96.9
Chamber 1	17	2621	102	2519	141	2378	96.1
	18	2621	77	2544	98	2446	97.1
	19	2621	158	2463	124	2339	94.0
	20	2621	90	2531	129	2402	96.6
2	17	2621	126	2495	126	2358	95.2
	18	2621	120	2501	135	2356	95.4
	19	2621	119	2502	124	2378	95.5
	20	2621	120	2501	116	2385	95.4
3	17	2621	94	2527	122	2405	96.4
	18	2621	143	2478	156	2322	94.5
	19	2621	40	2581	117	2464	98.5
	20	2621	52	2569	120	2449	98.0
4	17	2621	50	2571			98.1
	18	2621	116	2505	110	2395	95.6
	19	2621	114	2507	122	2385	95.7
	20	2621	66	2555	120	2435	97.5
5	17	2621	113	2508	111	2382	95.7
	18	2621	67	2554	130	2424	97.4
	19	2621	42	2579	112	2467	98.4
	20	2621	74	2547	132	2415	97.2

Blank spaces indicate no sample available for analysis.

TABLE X, continued

Condition (period)	Subject No.	Intake cal	Undigested in feces cal	Digestible cal	Excreted in urine cal	Metabo- lizable cal	Coefficient of apparent digestibility %
6	17	2621	84	2537			96.8
	18	2621	94	2527	114	2413	96.4
	19	2621	217	2404	121	2283	91.7
	20	2621	65	2556	122	2434	97.5
	17	2621	66	2555	63	2492	97.5
	18	2621	149	2472	56	2416	94.3
	19	2621					
	20	2621	22	2599	56	2543	99.2
<u>Condition Averages</u>							
Pre-Chamber		2621	78	2543	108	2435	97.0
Chamber		2621	98	2523	123	2400	96.3
Post-Chamber		2621	94	2527	58	2469	96.4
<u>Subject Averages</u>							
	17	2621	88	2533	113	2420	96.6
	18	2621	115	2506	111	2395	95.6
	19	2621	108	2513	119	2394	95.9
	20	2621	71	2540	113	2437	96.9
<u>Combined Subject Averages</u>							
		2621	96	2525	114	2411	96.3

Food acceptability data are presented in tables XI through XIV and these tables are summarized in table XV. Individual diet acceptability is extremely close to the combined average value of 7.2 (like moderately). On the basis of meal evaluation, meal D was rated the lowest and meals A and C the highest. Among the individual food items, fruits, juices, sausage, cereals, baked desserts, and cocoa were the most acceptable. Foods containing gravy or cream sauce were the least acceptable which may be related to the requirement that all food be consumed at room temperature. Certain food combinations were found objectionable by the subjects. Such criticisms may be related to the composition of the diet since meal balance in respect to protein, carbohydrate, fat, and caloric content was emphasized rather than meal content in respect to breakfast versus lunch or supper food items.

Body weight changes are presented in table XVI, and are tabulated as 3-day weight averages for the initial and final days of the separate experimental periods. The largest individual changes during the experiment were shown by subject 17 who lost 0.6 kg during the pre-chamber period and 1.1 kg during the chamber period, and subject 18 who lost 0.7 kg during the chamber period. Over-all changes were small as shown by the combined average values.

Body weight changes for the entire 6-week period have been related to nutrient intake as shown in table XVII. A maximum loss of 1.2 kg for subject 17 and a slight gain for subject 19 may be noted. These subjects were the heaviest and the lightest, respectively, of the four subjects. The caloric intake per kilogram of body weight is consistent with the limited activity of the subjects. Recommended caloric intake for men of this age group engaged in moderate physical activity, is approximately 45 kcal per day per kilogram of body weight (27). The recommended protein intake is approximately 1.0 g per day per kilogram of body weight (27) which is less than the average of 1.53 g per day per kilogram of body weight in this study. The higher protein intake is due to the higher protein content of the diet.

The summary of physiological measurements is presented in table XVIII. The measurements during the three specific experimental periods have been averaged. The heart rates at 0800 appear relatively consistent among the subjects during the three experimental periods. There was no significant variation in heart rates for chamber and control periods. The heart rates during exercise periods indicate consistent increases due to the stress, followed by decreases to pre-stress values. Subjects 17 and 20, the two heaviest subjects, showed lower over-all heart rates than subjects 18 and 19. Blood pressures were consistent between experimental periods and among subjects. Subject 19 had the lowest although constant blood pressure. Oral temperatures were normal at all times.

Water balance data is presented in table XIX. The average water content of the diets was determined and used to compute intake. Metabolic water was calculated according to Consolazio, et al. (28), taking into consideration the consumption and digestibility of each food constituent. The last column indicates the amount of water

TABLE XI
FOOD ACCEPTABILITY OF METABOLIC DIET 1

Food	Subject No.				Combined average
	17	18	19	20	
<u>Meal A</u>					
Grapefruit juice	9	9	8	4	7.5
Sugar frosted flakes	5	8	8	8	7.3
Beef and vegetables	7	5	6	5	5.8
Toast and butter	8	7	8	7	7.5
Cherries	8	9	9	7	8.3
Apricots	8	8	8	7	7.8
<u>Meal B</u>					
Corn chowder	4	4	4	7	4.8
Peanut butter sandwich	9	8	8	6	7.8
Roast beef	7	7	6	3	5.8
Potatoes and butter	7	4	7	3	5.3
Pound cake	9	9	8	8	8.5
<u>Meal C</u>					
Chicken sandwich	8	6	7	6	6.8
Canadian bacon	8	9	9	7	8.3
Toast and butter	7	7	8	7	7.3
Chocolate pudding	8	8	7	7	7.5
<u>Meal D</u>					
Roast beef	7	7	5	3	5.5
Toast and butter	7	7	7	6	6.8
Pineapple cake	9	9	8	7	8.3
Fruit cocktail	9	9	8	8	8.5
Tea and sugar	9	7	9	7	8.0

Food acceptability based upon a nine-point grading scale .

TABLE XII
FOOD ACCEPTABILITY OF METABOLIC DIET 2

Food	Subject No.				Combined average
	17	18	19	20	
<u>Meal A</u>					
Orange-grapefruit juice	9	9	8	7	8.3
Sugar frosted flakes and skimmed milk	9	8	8	8	8.3
Fried chicken	8	5	6	4	5.8
Cheese sandwich	8	6	8	6	7.0
Brownies	9	9	8	8	8.5
Tea and sugar	9	7	9	7	8.0
<u>Meal B</u>					
Beef and gravy	8	5	5	3	5.3
Potato salad	7	6	9	7	7.3
Cinnamon toast	8	9	9	8	8.5
Vanilla pudding	8	8	5	8	7.3
Apricots	9	9	8	7	8.3
<u>Meal C</u>					
Orange juice	9	8	8	7	8.0
Tuna salad	8	5	8	7	7.0
Toast	8	6	8	7	7.3
Mushroom soup	3	3	5	7	4.5
Apple sauce	9	9	8	8	8.5
<u>Meal D</u>					
All Star cereal and skimmed milk	9	9	9	8	8.8
Beef and rye bread	7	7	6	4	6.0
Creamed carrots	4	3	5	2	3.5
Toast and butter	7	7	4	7	6.3
Cocoa	9	9	9	8	8.8

Food acceptability based upon a nine-point grading scale.

TABLE XIII

FOOD ACCEPTABILITY OF METABOLIC DIET 3

Food	Subject No.				Combined average
	17	18	19	20	
<u>Meal A</u>					
Grapefruit juice	9	9	8	4	7.0
Bacon and egg	8	7	9	7	7.8
Chicken and vegetables	8	6	5	6	6.3
Butterscotch pudding	9	9	6	8	8.0
<u>Meal B</u>					
Grape juice	9	9	9	8	8.8
Sugar frosted flakes and skimmed milk	9	8	8	8	8.3
Toast and butter	8	8	8	8	8.0
Salmon salad	8	6	8	6	7.0
Tea and sugar	9	7	9	6	7.8
Fruit compote	8	9	9	7	8.3
<u>Meal C</u>					
Orange-pineapple juice	9	9	8	8	8.5
Spaghetti and meat	7	7	6	7	6.8
Beef and rye bread	8	7	7	5	6.8
Date cake	9	9	8	5	7.8
<u>Meal D</u>					
Potato soup	4	2	5	5	4.0
Shrimp and chili sauce	7	3	8	5	5.8
Pineapple	9	8	8	8	8.3
Gingerbread	9	6	8	6	7.3

Food acceptability based upon a nine-point grading scale.

TABLE XIV
FOOD ACCEPTABILITY OF METABOLIC DIET 4

Food	Subject No.				Combined average
	17	18	19	20	
Meal A					
Grape juice	9	9	9	8	8.8
Sausage	8	8	8	8	8.0
Toast	7	8	6	6	6.8
Cocoa	9	9	8	8	8.5
Meal B					
Chicken salad	7	6	6	7	6.5
Creamed green beans	7	3	7	5	5.5
Banana pudding	8	7	7	7	7.3
Tea and sugar	9	7	9	7	8.0
Meal C					
Blended juices	9	9	8	6	8.0
Ham and apple sauce	8	9	8	8	8.3
Peanut butter sandwich	9	8	8	6	7.8
Potato salad	8	7	9	7	7.8
Meal D					
Grape juice	9	8	9	8	8.5
Pea soup	3	2	2	2	2.3
Chicken and gravy	7	1	4	3	3.8
Apricots	9	8	8	7	8.0

Food acceptability based upon a nine-point grading scale .

TABLE XV
SUMMARY OF FOOD ACCEPTABILITIES

Meal	Metabolic diet				Average meal acceptability
	1	2	3	4	
A	7.4	7.7	7.3	8.0	7.6
B	6.4	7.3	8.0	6.8	7.1
C	7.5	7.1	7.5	8.0	7.5
D	7.4	6.7	6.4	5.7	6.6
Average diet acceptability	7.2	7.2	7.3	7.1	
Combined diet acceptability		7.2			

TABLE XVI
BODY WEIGHT CHANGE

Condition	Interval days	Subject No.	Body weight*		
			Initial	Final kg	Change
Pre-Chamber	7	17	76.1	75.5	- 0.6
		18	70.0	69.9	- 0.1
		19	68.0	68.2	0.2
		20	72.8	72.9	0.1
Chamber	28	17	75.5	74.4	- 1.1
		18	69.8	69.1	- 0.7
		19	68.2	68.8	0.6
		20	73.2	73.3	0.1
Post-Chamber	7	17	74.6	74.9	0.3
		18	68.5	69.0	0.5
		19	68.0	68.3	0.3
		20	72.3	72.3	0.0
<u>Combined average body weight change</u>					
Pre-Chamber			71.7	71.6	- 0.1
Chamber			71.7	71.4	- 0.3
Post-Chamber			70.8	71.1	0.3

* Values presented as three-day weight averages.

TABLE XVII
AVERAGE NUTRIENT INTAKE AS RELATED TO BODY WEIGHT

Subject No.	Body weight*			Caloric intake		Protein intake	
	Initial	Final	Change kg	kcal/day	kcal/day/kg body wt**	g/day	g/day/kg body wt**
17	76.1	74.9	- 1.2	2621	34.4	109.7	1.44
18	70.0	69.0	- 1.0	2621	37.4	109.7	1.57
19	68.0	68.3	+ 0.3	2621	38.5	109.7	1.61
20	72.8	72.3	- 0.5	2621	36.0	109.7	1.51

* Values presented as three-day weight averages.

** Based on initial body weight.

TABLE XVIII
SUMMARY OF PHYSIOLOGICAL MEASUREMENTS

Condition	Heart rate at 0800 hours			
	Subject No.			
	17	18	19	20
	beats/minute			
Pre-Chamber	72.3	71.3	76.0	75.3
Chamber	80.0	80.3	76.2	75.1
Post-Chamber	77.7	86.9	81.7	73.1

Heart rate during exercise at 2000 hours				
Chamber				
Pre-Exercise	73.0	79.9	80.0	68.0
Exercise	95.7	119.7	112.7	102.5
Post-Exercise	78.2	84.8	82.1	71.8

Heart rate during exercise at designated hours				
	1200hr	0700hr	1500hr	0400hr
Chamber				
Pre-Exercise	70.8	80.5	76.2	69.3
Exercise	102.9	119.8	114.8	108.8
Post-Exercise	77.2	79.1	83.5	74.7
Post-Exercise				
Pre-Exercise	81.0	80.3	81.0	73.4
Exercise	100.0	116.8	102.7	96.6
Post-Exercise	83.0	81.3	86.3	74.6

TABLE XVIII, continued

Condition	Blood pressure			
	Subject No.			
	17	18	19	20
	systolic/diastolic			
Pre-Chamber	124/83	120/73	112/76	124/76
Chamber	121/80	122/67	113/78	119/73
Post-Chamber	124/78	116/62	104/77	117/65
	Oral temperature °F			
	17	18	19	20
	17	18	19	20
	17	18	19	20
Pre-Chamber	97.1	97.5	97.7	98.0
Chamber	96.2	98.3	96.9	98.6
Post-Chamber	97.3	98.8	96.9	98.8

available for insensible water. The daily intake averaged 2537 ml of water with a daily output average of 1617 ml and 41 ml via the urine and feces, respectively. The combined subject average indicated a daily average insensible water loss via respiration and skin of 879 ml. This value is to be expected under the controlled conditions of temperature and humidity extant. The individual subject averages for the entire experiment are quite similar; all are within 5% or less of the combined average value.

The data resulting from chemical analyses of food and waste products have been utilized in the determination of various food and electrolyte balances and digestibilities. These data are presented in tables XX through XXIX. Each period within a given experimental condition represents a 4-day combined sample analysis. Periods listed in the tables correspond to the respective urine and feces samples listed in table II as follows: pre-chamber, U2, F1; chamber, U3, F2 through U8, F7; post-chamber, U10, F9. The balances are computed by subtracting from the intake of a constituent the amounts excreted in urine and feces. The coefficient of apparent digestibility of a food or electrolyte is calculated as the percent net intake of the actual intake, where the net intake is equal to the actual intake minus output in feces.

Fat digestibilities for all conditions among all subjects averaged 98% (table XX). There are no differences in nitrogen balance and digestibility in pre-chamber, chamber, and post-chamber conditions. All subjects maintained a positive nitrogen balance with a mean average of 1.0 g/24 hr. The mean value for digestibility is 93% (table

TABLE XIX
WATER BALANCE

Condition (period)	Subject No.	Water available				Water excreted			Water available for evaporation assuming water balance* ml
		Die- tary	Ad lib ml	Meta- bolic	Total	Urine	Feces ml	Total	
Pre-Chamber									
1	17	1544	778	299	2621	1610	27	1637	984
	18	1544	370	297	2211	1504	64	1568	643
	19	1544	833	299	2676	1738	31	1769	907
	20	1544	1120	298	2962	1644	38	1682	1280
Chamber									
1	17	1544	660	297	2501	1310	33	1343	1158
	18	1544	730	298	2572	1123	38	1161	1411
	19	1544	500	294	2338	1558	75	1633	705
	20	1544	1000	297	2841	1130	51	1181	1660
2	17	1544	500	296	2340	1370	46	1416	924
	18	1544	500	296	2340	1250	45	1295	1045
	19	1544	250	296	2090	1440	53	1493	597
	20	1544	**	296	1840	1090	66	1156	684
3	17	1544	500	298	2342	1650	35	1685	657
	18	1544	250	295	2089	1418	57	1475	614
	19	1544	750	300	2594	1544	17	1561	1033
	20	1544	250	299	2093	1463	19	1482	611
4	17	1544	1200	299	3043	2030	20	2050	993
	18	1544	1250	296	3090	2230	56	2286	804
	19	1544	769	296	2609	1578	51	1629	980
	20	1544	1165	299	3008	1829	28	1857	1151
5	17	1544	785	296	2625	1375	45	1420	1205
	18	1544	988	299	2831	1783	31	1814	1017
	19	1544	649	299	2492	1580	20	1600	892
	20	1544	896	297	2737	1810	34	1844	893

Daily average values for four-day combined period.

* Water evaporation via skin and respiratory system.

** No ad lib water consumed during period.

TABLE XIX, continued

Condition (period)	Subject No.	Water available				Water excreted			Water available for evaporation assuming water balance* ml
		Die- tary	Ad lib ml	Meta- bolic	Total	Urine	Feces ml	Total	
6	17	1544	615	298	2457	1926	47	1973	484
	18	1544	833	297	2674	1719	50	1769	905
	19	1544	506	292	2342	1633	68	1701	641
	20	1544	769	299	2612	1700	36	1736	876
Post-Chamber									
	17	1544	670	299	2513	1808	36	1844	669
	18	1544	1083	293	2920	2063	86	2149	771
	19	1544	1090	297	2931	2033		2033	898
	20	1544	1000	300	2844	1817	11	1828	1016
<u>Condition averages</u>									
Pre-Chamber		1544	775	298	2617	1624	40	1664	953
Chamber		1544	709	297	2521	1564	43	1607	914
Post-Chamber		1544	961	297	2802	1930	33	1963	839
<u>Subject averages</u>									
	17	1544	714	298	2556	1635	36	1671	885
	18	1544	751	296	2591	1636	53	1689	902
	19	1544	668	297	2509	1638	39	1677	832
	20	1544	886	298	2617	1560	35	1595	1021
<u>Combined subject averages</u>									
		1544	757	297	2568	1617	41	1658	910

XXI). The fiber digestibilities for all conditions and among all subjects averaged 80% (table XXII). These apparent digestibilities are enigmatic in view of the fact that mammalian tissues do not possess enzymes capable of degrading cellulose. Possible explanations are presented in the discussion. Ash digestibilities for all conditions and among all subjects averaged 85% (table XXIII). Within the limit of experimental error, no differences were found in phosphorus, sodium, potassium, chloride, magnesium, and calcium balances and digestibilities in pre-chamber, chamber, and post-chamber conditions (tables XXIV through XXIX). All subjects maintained a positive balance with respect to these minerals. The balances per day are as follows: phosphorus, 0.2 g; sodium, 0.8 g; potassium, 0.5 g; chloride, 0.1 g; magnesium, 0.05 g; and calcium, 0.09 g. The mean values for digestibilities are as follows: phosphorus, 77%; sodium, about 100%; potassium, 92%; chloride, 99+%; magnesium, 52%; and calcium, 28%.

Summary data of hematological and chemical analyses on blood samples are presented in tables XXX and XXXI. Mean values and standard deviations for the eight samples drawn during the experiment on each subject are presented. Larger standard deviations may be observed for hematological analyses in contrast to chemical analyses as would be expected. Data for both hematological and chemical analyses showed no significant differences relative to the experimental conditions of pre-chamber, chamber, and post-chamber, and were averaged to provide combined subject averages as shown in the last column of each table. All data fall within the normal clinical range. Of the chemical analyses, only creatinine was found to show a variance of one standard deviation greater than 10%, with glucose, calcium, and phosphorus between 5% and 10%, and sodium and chloride less than 5% over the 6-week experimental period. The relatively narrow variation in blood chemical values for these subjects as compared to the larger variations observed in individuals from a normal population on an uncontrolled diet may be attributed to the metabolic equilibrium induced by the controlled dietary conditions.

Figures 1 through 10 show the excretion patterns obtained for each subject with respect to a particular constituent or parameter; the cumulative outputs are plotted against time. In each figure, the pre-chamber, chamber, and post-chamber periods are delineated. In general, good linear outputs are obtained as can be seen for creatinine, nitrogen, and the minerals sodium, potassium, chloride, and phosphate. The divalent cations calcium and magnesium show inflections in the output curves with a tendency to greater outputs presumably due to adjustments in dietary intake. These data merely indicate that a ten to fourteen day period is required to obtain steady-state base line outputs. Table XXXII summarizes the mean 24-hour outputs over the entire experiment. These values have been computed because analysis of the output curves do not reveal any significant changes between pre-chamber, chamber, and post-chamber intervals. All the data fall within the clinically normal range. The deviations among the subjects are small and in most instances the lowest value is not more than 10% from the highest value with the exception of the divalent cations, calcium and magnesium. These fluctuations merely reflect the relatively low and variable apparent digestibilities of these divalent mineral elements.

TABLE XX
FAT DIGESTIBILITY

Condition (period)	Subject No.	Intake g	Excretion in feces g	Coefficient of apparent digestibility %
Pre-Chamber	17	320.5	6.1	98.1
	18	320.5	8.3	97.4
	19	320.5	4.3	98.7
	20	320.5	6.1	98.1
Chamber 1 2 3 4 5	17	320.5	7.8	97.6
	18	320.5	6.3	98.0
	19	320.5	9.6	97.0
	20	320.5	5.2	98.4
	17	320.5	11.1	96.5
	18	320.5	8.1	97.5
	19	320.5	7.3	97.7
	20	320.5	6.6	97.9
	17	320.5	8.3	97.4
	18	320.5	10.5	96.7
	19	320.5	2.9	99.1
	20	320.5	4.1	98.7
	17	320.5	5.0	98.4
	18	320.5	7.8	97.6
	19	320.5	6.0	98.1
	20	320.5	3.7	98.8
	17	320.5	8.7	97.3
	18	320.5	5.6	98.3
	19	320.5	3.4	98.9
	20	320.5	5.7	98.2

Blank spaces indicate no sample available for analysis.

TABLE XX, continued

Condition (period)	Subject No.	Intake g	Excretion in feces g	Coefficient of apparent digestibility %
6	17	320.5	8.3	97.4
	18	320.5	5.0	98.4
	19	320.5	17.3	94.6
	20	320.5	5.7	98.2
Post-Chamber	17	320.5	5.7	98.2
	18	320.5		
	19	320.5	4.9	98.5
	20	320.5	1.4	99.6
<u>Condition Averages</u>				
Pre-Chamber		320.5	6.2	98.1
Chamber		320.5	7.1	97.8
Post-Chamber		320.5	4.0	98.8
<u>Subject Averages</u>				
	17	320.5	7.6	97.6
	18	320.5	7.4	97.7
	19	320.5	7.0	97.8
	20	320.5	4.8	98.5
<u>Combined Subject Averages</u>				
		320.5	6.7	97.9

TABLE XXI
NITROGEN BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
Pre-Chamber	17	70.2	3.4	65.6	69.0	1.2	0.3	95.2
	18	70.2	5.0	61.6	66.5	3.7	0.9	92.9
	19	70.2	3.7	44.8	48.5	21.7	5.4	94.7
	20	70.2	4.2	40.8	45.0	25.2	6.3	94.0
Chamber	17	70.2	5.0	68.0	73.0	- 2.8	- 0.7	92.9
	18	70.2	3.9	58.2	62.1	8.1	2.0	94.4
	19	70.2	8.3	60.8	69.1	1.1	0.3	88.2
	20	70.2	4.8	69.6	74.4	- 4.2	- 1.1	93.2
	17	70.2	6.3	64.8	71.1	- 0.9	- 0.2	91.0
	18	70.2	6.2	63.1	69.3	0.9	0.2	91.2
	19	70.2	6.5	65.5	72.0	- 1.8	- 0.5	90.7
	20	70.2	6.3	56.8	63.1	7.1	1.8	91.0
	17	70.2	4.6	66.3	70.9	- 0.7	- 0.2	93.4
	18	70.2	7.7	54.2	61.9	8.3	2.1	89.0
	19	70.2	2.0	61.5	63.5	1.7	6.7	97.2
	20	70.2	2.9	60.8	63.7	6.5	1.6	95.9
	17	70.2	2.5	58.6	61.1	9.1	2.3	96.4
	18	70.2	6.2	58.9	65.1	5.1	1.3	91.2
	19	70.2	6.3	60.0	66.3	3.9	1.0	91.0
	20	70.2	3.5	63.5	67.0	3.2	0.8	95.0
	17	70.2	5.7	57.5	63.2	7.0	1.8	91.9
	18	70.2	3.4	58.2	61.6	8.6	2.2	95.2
	19	70.2	2.3	61.6	63.9	6.3	1.6	96.7
	20	70.2	4.7	58.7	63.4	6.8	1.7	93.3

* Nitrogen content of sweat not accounted for in this balance.

TABLE XXI, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
6	17	70.2	4.5	56.2	60.7	9.5	2.4	93.6
	18	70.2	5.3	68.0	73.3	- 3.1	- 0.8	92.3
	19	70.2	11.3	71.1	82.1	- 11.9	- 3.0	83.9
	20	70.2	3.5	57.3	60.8	9.4	2.4	95.0
Post-Chamber	17	70.2	3.4	67.8	71.2	- 1.0	- 0.3	95.2
	18	70.2	8.7	57.0	65.7	4.5	1.1	87.6
	19	70.2	5.4	59.9	65.3	4.9	1.2	92.3
	20	70.2	1.3	61.5	62.8	7.4	1.9	98.1
<u>Condition Averages</u>								
Pre-Chamber		70.2	4.1	58.2	62.3	7.9	2.0	94.2
Chamber		70.2	5.1	61.8	66.8	3.4	0.9	92.7
Post-Chamber		70.2	4.7	61.6	66.3	3.9	1.0	93.3
<u>Subject Averages</u>								
	17	70.2	4.4	63.1	67.5	2.7	0.8	93.7
	18	70.2	5.8	59.9	65.7	4.5	1.1	91.7
	19	70.2	5.7	60.7	66.4	3.8	1.0	91.9
	20	70.2	3.9	61.1	65.0	5.2	1.3	94.4
<u>Combined Subject Averages</u>								
		70.2	4.4	61.2	66.2	4.0	1.0	92.9

TABLE XXII
FIBER DIGESTIBILITY

Condition (period)	Subject No.	Intake g	Excretion in feces g	Coefficient of apparent digestibility %
Pre-Chamber	17	29.5	4.3	85.4
	18	29.5	5.9	80.0
	19	29.5	4.4	85.1
	20	29.5	6.1	79.3
Chamber 1 2 3 4 5	17	29.5	5.0	83.0
	18	29.5	5.1	82.7
	19	29.5	8.5	71.2
	20	29.5	6.5	78.0
	17	29.5	5.2	82.4
	18	29.5	8.8	70.2
	19	29.5	6.9	76.6
	20	29.5	6.1	79.3
	17	29.5	6.4	78.2
	18	29.5	8.6	70.8
	19	29.5	2.4	91.8
	20	29.5	1.7	94.2
	17	29.5	2.6	91.2
	18	29.5	6.5	78.0
	19	29.5	6.2	79.0
	20	29.5	2.7	90.8
	17	29.5	10.0	66.1
	18	29.5	5.9	80.0
	19	29.5	2.8	90.5
	20	29.5	2.7	90.8

Blank spaces indicate no sample available for analysis.

TABLE XXII, continued

Condition (period)	Subject No.	Intake g	Excretion in feces g	Coefficient of apparent digestibility %
6	17	29.5	6.0	79.6
	18	29.5	5.2	82.4
	19	29.5	20.2	31.5
	20	29.5	2.8	90.5
Post-Chamber	17	29.5	4.5	84.7
	18	29.5		
	19	29.5	8.9	69.8
	20	29.5	1.1	96.3
<u>Condition Averages</u>				
Pre-Chamber		29.5	5.2	82.4
Chamber		29.5	6.0	79.5
Post-Chamber		29.5	4.8	83.6
<u>Subject Averages</u>				
	17	29.5	5.6	81.3
	18	29.5	6.6	77.7
	19	29.5	7.5	74.4
	20	29.5	3.7	87.4
<u>Combined Subject Averages</u>				
		29.5	5.8	80.2

TABLE XXIII
ASH DIGESTIBILITY

Condition (period)	Subject No.	Intake g	Excretion in feces g	Coefficient of apparent digestibility %
Pre-Chamber	17	73.3	6.4	91.3
	18	73.3	9.9	86.3
	19	73.3	7.8	89.3
	20	73.3	10.5	85.7
Chamber	17	73.3	9.4	87.2
	18	73.3	8.4	88.5
	19	73.3	18.5	74.8
	20	73.3	11.5	84.3
	17	73.3	12.2	83.3
	18	73.3	10.5	85.7
	19	73.3	10.6	85.5
	20	73.3	15.0	79.5
	17	73.3	8.6	88.3
	18	73.3	13.1	82.1
	19	73.3	4.3	94.1
	20	73.3	7.4	89.9
	17	73.3	4.5	93.8
	18	73.3	10.8	85.3
	19	73.3	12.4	83.1
	20	73.3	7.9	89.2
	17	73.3	8.4	88.5
	18	73.3	7.1	90.3
	19	73.3	5.5	92.5
	20	73.3	12.8	82.5

TABLE XXIII, continued

Condition (period)	Subject No.	Intake g	Excretion in feces g	Coefficient of apparent digestibility %
6	17	73.3	7.8	88.5
	18	73.3	8.9	87.8
	19	73.3	22.7	69.0
	20	73.3	9.3	87.3
Post-Chamber	17	73.3	6.8	90.7
	18	73.3		
	19	73.3	8.9	87.8
	20	73.3	2.5	96.5
<u>Condition Averages</u>				
Pre-Chamber		73.3	8.7	88.1
Chamber		73.3	10.3	85.9
Post-Chamber		73.3	6.1	91.7
<u>Subject Averages</u>				
	17	73.3	8.0	89.1
	18	73.3	9.8	86.6
	19	73.3	11.3	84.5
	20	73.3	9.6	87.3
<u>Combined Subject Averages</u>				
		73.3	9.7	86.8

TABLE XXIV
PHOSPHORUS BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
Pre-Chamber								
	17	5.49	0.75	3.75	4.50	0.99	0.25	86.3
	18	5.49	1.20	3.43	4.63	0.86	0.22	78.1
	19	5.49	0.88	2.84	3.72	1.77	0.44	84.0
	20	5.49	1.63	2.82	4.45	1.04	0.26	70.3
Chamber								
1	17	5.49	1.16	4.51	5.66	- 0.17	- 0.04	78.9
	18	5.49	1.01	3.24	4.25	1.24	0.31	81.6
	19	5.49	2.18	3.84	6.02	- 0.53	- 0.13	60.3
	20	5.49	1.78	3.05	4.83	0.66	0.17	67.6
2	17	5.49	1.60	2.31	3.91	1.58	0.40	70.9
	18	5.49	1.59	3.04	4.63	0.86	0.22	71.0
	19	5.49	1.38	2.88	4.26	1.23	0.31	74.9
	20	5.49	2.13	2.72	4.85	0.64	0.16	61.2
3	17	5.49	1.18	3.73	4.91	0.58	0.15	78.5
	18	5.49	1.79	3.14	4.93	0.56	0.14	67.4
	19	5.49	0.54	3.26	3.80	1.69	0.42	90.2
	20	5.49	0.80	3.36	4.16	1.33	0.33	85.4
4	17	5.49	0.68	3.40	4.08	1.41	0.35	87.6
	18	5.49	1.34	3.72	5.06	0.43	0.11	75.6
	19	5.49	1.59	3.75	5.34	0.12	0.03	71.0
	20	5.49	1.24	3.23	4.47	1.02	0.25	77.4
5	17	5.49	1.43	3.52	4.95	0.54	0.14	74.0
	18	5.49	0.80	3.87	4.67	0.82	0.21	85.4
	19	5.49	0.51	3.84	4.35	1.14	0.29	90.7
	20	5.49	1.31	3.22	4.53	0.96	0.24	76.1

* Phosphorus content of sweat not accounted for in this balance.

TABLE XXIV, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
6	17	5.49	1.02	4.20	5.22	0.27	0.07	81.4
	18	5.49	1.16	3.71	4.87	0.62	0.16	78.9
	19	5.49	2.94	4.13	7.07	- 1.58	- 0.40	46.4
	20	5.49	1.94	3.88	5.82	- 0.33	- 0.08	64.7
Post-Chamber								
	17	5.49	0.90	3.90	4.80	0.69	0.17	83.6
	18	5.49		2.99				
	19	5.49	1.23	3.18	4.41	0.99	0.25	77.6
	20	5.49	0.40	2.56	2.96	2.53	0.63	92.7
<u>Condition Averages</u>								
Pre-Chamber		5.49	1.12	3.21	4.33	1.16	0.29	79.6
Chamber		5.49	1.38	3.48	4.86	0.63	0.16	74.9
Post-Chamber		5.49	0.84	3.16	4.00	1.49	0.37	84.7
<u>Subject Averages</u>								
	17	5.49	1.09	3.67	4.76	0.73	0.18	80.1
	18	5.49	1.27	3.39	4.66	0.83	0.21	76.9
	19	5.49	1.41	3.47	4.88	0.61	0.15	74.3
	20	5.49	1.40	3.11	4.51	0.98	0.25	74.5
<u>Combined Subject Averages</u>								
		5.49	1.29	3.41	4.70	0.79	0.20	76.5

Blank spaces indicate no sample available for analysis.

TABLE XXV

SODIUM BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96hr	Excretion			Balance*		
			Feces	Urine g/96 hr	Total	g/96hr	g/24hr	
Pre-Chamber	17	15.4	0.012	11.50	11.5	3.9	1.0	
	18	15.4	0.200	11.50	11.7	3.7	0.9	
	19	15.4	0.038	8.80	8.8	6.6	1.7	
	20	15.4	0.023	11.38	11.4	4.0	1.0	
Chamber	17	15.4	0.021	11.50	11.5	3.9	1.0	
	1	18	15.4	0.068	10.84	10.9	4.5	1.1
	19	15.4	0.106	12.61	12.7	2.7	0.7	
	20	15.4	0.029	10.40	10.4	5.0	1.3	
	2	17	15.4	0.030	10.24	10.3	5.1	1.3
	18	15.4	0.056	14.72	14.8	0.6	0.2	
	19	15.4	0.081	12.61	12.7	2.7	0.7	
	20	15.4	0.056	14.40	14.5	0.9	0.2	
	3	17	15.4	0.019	12.26	12.3	3.1	0.8
	18	15.4	0.057	12.12	12.2	3.2	0.8	
	19	15.4	0.028	10.54	10.6	4.8	1.2	
	20	15.4	0.016	13.50	13.5	1.9	0.5	
	4	17	15.4	0.013	11.52	11.5	3.9	1.0
	18	15.4	0.081	13.80	13.9	1.5	0.4	
	19	15.4	0.062	11.15	11.2	4.2	1.3	
	20	15.4	0.021	13.40	13.4	2.0	0.5	
	5	17	15.4	0.025	11.32	11.4	4.0	1.0
	18	15.4	0.027	13.10	13.1	2.3	0.6	
	19	15.4	0.018	12.50	12.5	2.9	0.7	
	20	15.4	0.026	12.10	12.1	3.3	0.8	

* Sodium content of sweat not accounted for in this balance.

TABLE XXV, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*	
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr
6	17	15.4	0.045	15.10	15.1	0.3	0.1
	18	15.4	0.128	14.40	14.5	0.9	0.2
	19	15.4	0.056	14.25	14.3	1.1	0.3
	20	15.4	0.019	15.25	15.3	0.1	0.03
Post-Chamber	17	15.4	0.034	12.10	12.1	3.2	0.8
	18	15.4		10.50	10.5	4.9	1.2
	19	15.4	0.108	11.59	11.7	4.7	1.2
	20	15.4	0.011	9.10	9.1	6.3	1.6
<u>Condition Averages</u>							
Pre-Chamber		15.4	0.683	10.8	10.8	4.6	1.2
Chamber		15.4	0.453	12.7	12.7	2.7	0.7
Post-Chamber		15.4	0.051	10.8	10.8	4.6	1.2
<u>Subject Averages</u>							
	17	15.4	0.025	11.9	11.9	3.5	0.9
	18	15.4	0.088	12.6	12.6	2.8	0.7
	19	15.4	0.062	11.8	11.8	3.6	0.9
	20	15.4	0.025	12.4	12.4	3.0	0.8
<u>Combined Subject Averages</u>							
		15.4	0.050	12.2	12.2	3.2	0.8
<u>Apparent Digestibility</u>							
Minimum 99%							

Blank space indicates no sample available for analysis.

TABLE XXVI
POTASSIUM BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
Pre-Chamber	17	11.8	0.50	8.40	8.90	2.9	0.7	95.8
	18	11.8	0.91	8.90	9.81	2.0	0.5	92.4
	19	11.8	0.63	6.24	6.87	4.9	1.1	94.9
	20	11.8	1.19	8.83	10.01	1.8	0.5	89.8
Chamber 1	17	11.8	0.70	10.70	11.40	0.4	0.1	94.1
	18	11.8	0.67	8.74	9.41	1.4	0.4	94.1
	19	11.8	1.30	9.60	10.90	0.9	0.2	89.0
	20	11.8	1.41	9.63	11.04	0.8	0.2	88.1
	2	17	11.8	0.80	7.20	3.8	1.0	93.2
		18	11.8	0.86	10.10	0.8	0.2	92.4
		19	11.8	1.10	8.30	2.4	0.6	90.7
		20	11.8	1.72	9.45	0.6	0.2	85.6
	3	17	11.8	0.68	9.40	1.1	0.3	94.1
		18	11.8	1.17	9.70	0.9	0.2	89.8
		19	11.8	0.35	7.50	3.9	1.0	96.6
		20	11.8	0.71	9.10	2.0	0.5	94.1
	4	17	11.8	0.62	8.83	2.3	0.6	94.9
		18	11.8	1.03	11.40	- 0.6	- 0.2	91.5
		19	11.8	1.06	8.10	2.6	0.7	90.7
		20	11.8	0.82	9.45	1.5	0.4	93.2
	5	17	11.8	0.73	8.78	2.3	0.6	94.1
		18	11.8	0.58	9.00	2.2	0.6	94.9
		19	11.8	0.33	9.91	1.6	0.4	97.5
		20	11.8	1.20	7.90	2.7	0.7	89.8

* Potassium content of sweat not accounted for in this balance .

TABLE XXVI, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
6	17	11.8	0.78	10.75	11.53	0.3	0.1	93.2
	18	11.8	0.82	10.10	10.92	0.9	0.2	93.2
	19	11.8	1.50	9.60	11.50	0.3	0.1	87.3
	20	11.8	0.66	8.80	9.46	2.3	0.6	94.1
Post-Chamber	17	11.8	0.45	9.90	10.35	1.4	0.4	95.8
	18	11.8		8.00	8.00	3.8	1.0	
	19	11.8	0.44	8.05	8.49	3.3	0.8	96.6
	20	11.8	1.50	6.55	8.05	3.7	0.9	87.3
<u>Condition Averages</u>								
Pre-Chamber		11.8	0.81	8.09	8.90	2.9	0.7	93.2
Chamber		11.8	0.90	9.25	10.15	1.6	0.4	92.4
Post-Chamber		11.8	0.80	8.13	8.93	2.9	0.7	93.2
<u>Subject Averages</u>								
	17	11.8	0.66	9.25	9.91	1.9	0.5	94.1
	18	11.8	0.86	9.49	10.35	1.4	0.4	92.4
	19	11.8	0.84	8.41	9.25	2.5	0.6	93.2
	20	11.8	1.15	8.71	9.86	1.9	0.5	89.8
<u>Combined Subject Averages</u>								
		11.8	0.88	8.97	9.85	1.9	0.5	92.4

Blank space indicates no sample available for analysis.

TABLE XXVII
CHLORIDE BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*	
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr
Pre-Chamber	17	42.31	0.09	35.10	35.19	7.10	1.8
	18	42.31	0.31	40.51	40.82	1.49	0.4
	19	42.31	0.07	31.40	31.47	10.84	2.7
	20	42.31	0.11	52.32	52.43	- 10.12	- 2.5
Chamber	17	42.31		37.06	37.06	5.25	1.3
	18	42.31	0.12	33.46	33.58	8.73	2.2
	19	42.31	0.16	35.59	35.75	6.56	1.6
	20	42.31	0.18	42.97	43.15	- 0.84	- 0.2
	17	42.31	0.12	46.58	46.70	- 4.39	- 1.1
	18	42.31	0.11	42.64	42.75	- 0.44	- 0.1
	19	42.31	0.12	51.61	51.63	- 9.32	- 2.3
	20	42.31	0.28	43.30	43.58	- 1.27	- 0.3
	17	42.31		39.20	39.20	3.11	0.8
	18	42.31	0.17	44.20	44.37	- 2.06	- 0.5
	19	42.31	0.04	46.58	46.62	- 4.31	- 1.1
	20	42.31		42.15	42.15	- 0.16	0.0
	17	42.31		37.88	37.88	4.43	1.1
	18	42.31		52.48	52.48	- 10.17	- 2.5
	19	42.31	0.12	42.64	42.76	- 0.45	- 0.1
	20	42.31	0.08	48.38	48.36	- 6.15	- 1.5
	17	42.31	0.12	36.79	36.91	5.40	1.4
	18	42.31		33.29	33.29	9.02	2.3
	19	42.31		46.99	46.99	- 4.68	- 1.2
	20	42.31		37.63	37.63	4.68	1.2

Chloride expressed as sodium chloride. Blank spaces indicate no sample available for analysis.

* Chloride content of sweat not accounted for in this balance.

TABLE XXVII, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*	
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr
6 Post-Chamber	17	42.31	0.10	38.87	38.97	3.34	0.8
	18	42.31	0.14	50.84	50.98	- 8.67	- 2.2
	19	42.31	0.23	46.72	46.95	- 4.64	- 1.2
	20	42.31	0.08	36.00	36.08	6.23	1.6
	17	42.31	0.08	39.36	39.44	2.87	0.7
	18	42.31		37.56	37.56	4.75	1.2
	19	42.31	0.17	53.55	53.72	- 11.41	- 2.9
	20	42.31	0.03	38.05	38.08	4.23	1.1
<u>Condition Averages</u>							
Pre-Chamber		42.31	0.15	39.83	39.98	2.33	0.6
Chamber		42.31	0.14	42.24	42.38	- 0.07	0.0
Post-Chamber		42.31	0.09	42.13	42.22	- 0.09	0.0
<u>Subject Averages</u>							
	17	42.31	0.10	38.86	38.96	3.35	0.8
	18	42.31	0.17	41.87	42.04	0.27	0.1
	19	42.31	0.13	44.39	44.52	- 2.21	- 0.6
	20	42.31	0.13	42.60	42.73	- 0.42	- 0.1
<u>Combined Subject Averages</u>							
		42.31	0.13	41.93	42.06	0.25	0.1
<u>Apparent Digestibility</u>							
	Minimum	99.3%		Maximum	99.9%		

TABLE XXVIII
MAGNESIUM BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
Pre-Chamber								
1	17	1.15	0.36	0.37	0.73	0.42	0.11	68.7
	18	1.15	0.45	0.46	0.91	0.24	0.06	60.9
	19	1.15	0.40	0.35	0.75	0.40	0.11	65.2
	20	1.15	0.61	0.26	0.87	0.28	0.07	47.0
Chamber								
1	17	1.15	0.61	0.42	1.03	0.12	0.03	47.0
	18	1.15	0.40	0.15	0.55	0.60	0.15	65.2
	19	1.15	0.98	0.36	1.34	- 0.19	- 0.05	14.8
	20	1.15	0.68	0.30	0.98	0.17	0.04	40.9
2	17	1.15	0.91	0.35	1.26	- 0.11	- 0.02	20.8
	18	1.15	0.60	0.22	0.82	0.33	0.08	47.8
	19	1.15	0.71	0.42	1.13	0.02	0.01	38.3
	20	1.15	0.84					27.0
3	17	1.15	0.54	0.47	1.01	0.14	0.04	53.0
	18	1.15	0.80	0.53	1.33	- 0.18	- 0.05	30.4
	19	1.15	0.23	0.50	0.73	0.42	0.11	80.0
	20	1.15	0.35	0.31	0.66	0.49	0.12	69.6
4	17	1.15	0.32	0.40	0.72	0.43	0.11	72.2
	18	1.15	0.58	0.44	1.02	0.13	0.03	49.6
	19	1.15	0.68	0.49	1.17	- 0.02	- 0.01	40.9
	20	1.15	0.48	0.40	0.88	0.27	0.07	58.3
5	17	1.15	0.71	0.42	1.13	0.02	0.01	38.3
	18	1.15	0.29	0.42	0.71	0.44	0.11	24.8
	19	1.15	0.25	0.48	0.73	0.42	0.11	78.3
	20	1.15	0.58	0.35	0.93	0.22	0.06	49.6

Blank spaces indicate no sample available for analysis.

* Magnesium content of sweat not accounted for in this balance.

TABLE XXVIII, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
6	17	1.15	0.52	0.38	0.90	0.25	0.06	54.8
	18	1.15	0.54	0.53	1.07	0.08	0.02	53.0
	19	1.15	1.13	0.58	1.71	- 0.56	- 0.14	
	20	1.15	0.40	0.37	0.77	0.38	0.10	65.2
Post-Chamber								
	17	1.15	0.40	0.45	0.85	0.30	0.08	65.2
	18	1.15		0.36				
	19	1.15	0.49	0.34	0.83	0.32	0.08	57.4
	20	1.15	0.14	0.37	0.51	0.64	0.16	87.8
<u>Condition Averages</u>								
Pre-Chamber		1.15	0.46	0.36	0.82	0.33	0.08	60.0
Chamber		1.15	0.59	0.40	0.99	0.16	0.04	48.7
Post-Chamber		1.15	0.34	0.38	0.72	0.43	0.11	70.4
<u>Subject Averages</u>								
	17	1.15	0.55	0.41	0.96	0.19	0.05	52.2
	18	1.15	0.52	0.39	0.91	0.24	0.06	54.8
	19	1.15	0.61	0.44	1.05	0.10	0.03	47.0
	20	1.15	0.51	0.34	0.85	0.30	0.08	55.7
<u>Combined Subject Averages</u>								
		1.15	0.55	0.40	0.95	0.20	0.05	52.2

TABLE XXIX
CALCIUM BALANCE AND DIGESTIBILITY

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
Pre-Chamber								
	17	3.09	1.30	0.64	1.94	1.15	0.29	57.9
	18	3.09	2.00	0.40	2.40	0.69	0.17	35.3
	19	3.09	1.70	0.39	2.09	1.00	0.25	45.0
	20	3.09	2.20	0.37	2.57	0.52	0.13	28.8
Chamber								
1	17	3.09	2.30	0.70	3.00	0.09	0.02	25.6
	18	3.09	1.93	0.36	2.29	0.80	0.20	37.5
	19	3.09	4.30	0.50	4.80	- 1.71	- 0.43	
	20	3.09	2.50	0.48	2.98	0.11	0.03	19.1
2	17	3.09	2.70	0.41	3.11	- 0.02	- 0.01	12.6
	18	3.09	2.92	0.22	3.14	- 0.05	- 0.01	5.5
	19	3.09	2.55	0.24	2.79	0.30	0.08	17.5
	20	3.09	3.00	0.19	3.19	- 0.10	- 0.02	2.9
3	17	3.09	2.10	0.86	2.96	0.13	0.03	32.0
	18	3.09	3.40	0.41	3.81	- 0.72	- 0.18	
	19	3.09	0.92	0.62	1.54	1.55	0.39	70.2
	20	3.09	1.20	0.57	1.77	1.32	0.33	61.2
4	17	3.09	1.00	0.76	1.76	1.33	0.33	67.6
	18	3.09	2.60	0.37	2.97	0.12	0.03	15.9
	19	3.09	3.04	0.64	3.68	- 0.59	- 0.15	1.6
	20	3.09	1.80	0.54	2.34	0.75	0.19	41.7
5	17	3.09	2.74	0.84	3.58	- 0.49	- 0.12	11.3
	18	3.09	1.70	0.37	2.07	1.02	0.26	45.0
	19	3.09	1.20	0.67	1.87	1.22	0.31	61.2
	20	3.09	2.10	0.45	2.55	0.54	0.14	32.0

Blank spaces indicate no sample available for analysis.

* Calcium content of sweat not accounted for in this balance.

TABLE XXIX, continued

Condition (period)	Subject No.	Intake g/96 hr	Excretion			Balance*		Coefficient of apparent digestibility %
			Feces	Urine g/96 hr	Total	g/96 hr	g/24 hr	
6	17	3.09	2.00	0.67	2.67	0.42	0.13	35.3
	18	3.09	2.20	0.41	2.61	0.48	0.12	28.8
	19	3.09	5.50	0.80	6.30	- 3.21	- 0.80	
	20	3.09	1.74	0.54	2.28	0.81	0.20	43.7
Post-Chamber								
	17	3.09	1.43	0.72	2.15	0.94	0.24	53.7
	18	3.09		0.29				
	19	3.09	2.20	0.54	2.74	0.35	0.09	28.8
	20	3.09	0.55	0.60	1.15	1.94	0.49	82.2
<u>Condition Averages</u>								
Pre-Chamber		3.09	1.80	0.45	2.25	0.84	0.21	41.7
Chamber		3.09	2.39	0.53	2.92	0.17	- 0.04	22.7
Post-Chamber		3.09	1.39	0.54	1.92	1.17	0.29	55.0
<u>Subject Averages</u>								
	17	3.09	1.95	0.70	2.65	0.44	0.11	36.9
	18	3.09	2.39	0.35	2.74	0.35	0.09	22.7
	19	3.09	2.68	0.55	3.23	- 0.14	- 0.04	13.3
	20	3.09	1.89	0.47	2.36	0.73	0.18	38.8
<u>Combined Subject Averages</u>								
		3.09	2.23	0.52	2.75	0.34	0.09	27.9

TABLE XXX
SUMMARY OF HEMATOLOGICAL ANALYSES ON BLOOD

Constituent*	Units	Mean ± Standard deviation				Combined average
		Subject No.				
		17	18	19	20	
White blood cells	mm ³	6407	6929	5800	8111	6812
	±	616	1100	905	1380	
Total eosinophils	mm ³	105	196	110	140	138
	±	32	18	20	44	
Hematocrit	vol %	44	42	42	42	43
	●	2	2	2	3	
Hemoglobin	g %	16.2	15.6	15.6	16.0	15.9
	±	0.1	0.4	0.4	0.5	
Segmented Neutrophils	mm ³	3726	3725	3526	4475	3863
	±	648	840	1190	880	
Lymphocytes	mm ³	2304	2786	2017	3190	2574
	±	341	700	543	800	
Monocytes	mm ³	147	151	93	137	132
	±	69	61	70	106	

* Segmented neutrophils, lymphocytes, and monocytes determined as percent cells in Schilling differential blood examination. Values in cubic millimeters determined in respect to white blood cell count.

TABLE XXXI

SUMMARY OF CHEMICAL ANALYSES ON BLOOD

Constituent	Units	Mean ± Standard Deviation				Combined average
		Subject No.				
		17	18	19	20	
Glucose	mg%	74	75	77	82	77.0
	±	4	6	5	11	
Calcium	mg%	9.4	9.2	9.1	9.4	9.3
	±	0.8	0.7	0.4	0.6	
Phosphorus	mg%	3.1	2.8	3.0	2.8	2.9
	±	0.2	0.3	0.3	0.2	
Sodium	mEq/l	142	141	143	142	142
	±	2	2	2	2	
Potassium	mEq/l	5.0	4.9	5.0	4.9	5.0
	±	0.3	0.3	0.3	0.2	
Chloride	mEq/l	104	104	104	103	104
	•	1	1	4	3	
Creatinine	mg%	1.4	1.6	1.6	1.6	1.6
	±	0.2	0.2	0.1	0.3	

TABLE XXXII
SUMMARY OF ANALYSES ON URINE

Constituent	Units	Mean			
		Subject No.			
		17	18	19	20
Daily excretion	l/24 hr	1.59	1.66	1.72	1.59
Specific gravity		1.113	1.103	1.098	1.107
Total solids	g%	3.90	3.61	3.46	3.75
Nitrogen	g/24 hr	15.82	14.96	15.16	14.69
Creatinine	g/24 hr	1.97	1.76	1.92	1.91
Calcium	g/24 hr	0.17	0.09	0.14	0.12
Phosphorus	g/24 hr	0.87	0.88	0.93	0.77
Sodium	g/24 hr	2.77	3.23	3.04	3.20
Potassium	g/24 hr	2.27	2.44	2.23	2.16
Chloride*	g/24 hr	9.94	10.34	10.84	10.66
Magnesium	g/24 hr	0.10	0.09	0.11	0.08

* Chloride expressed as sodium chloride.

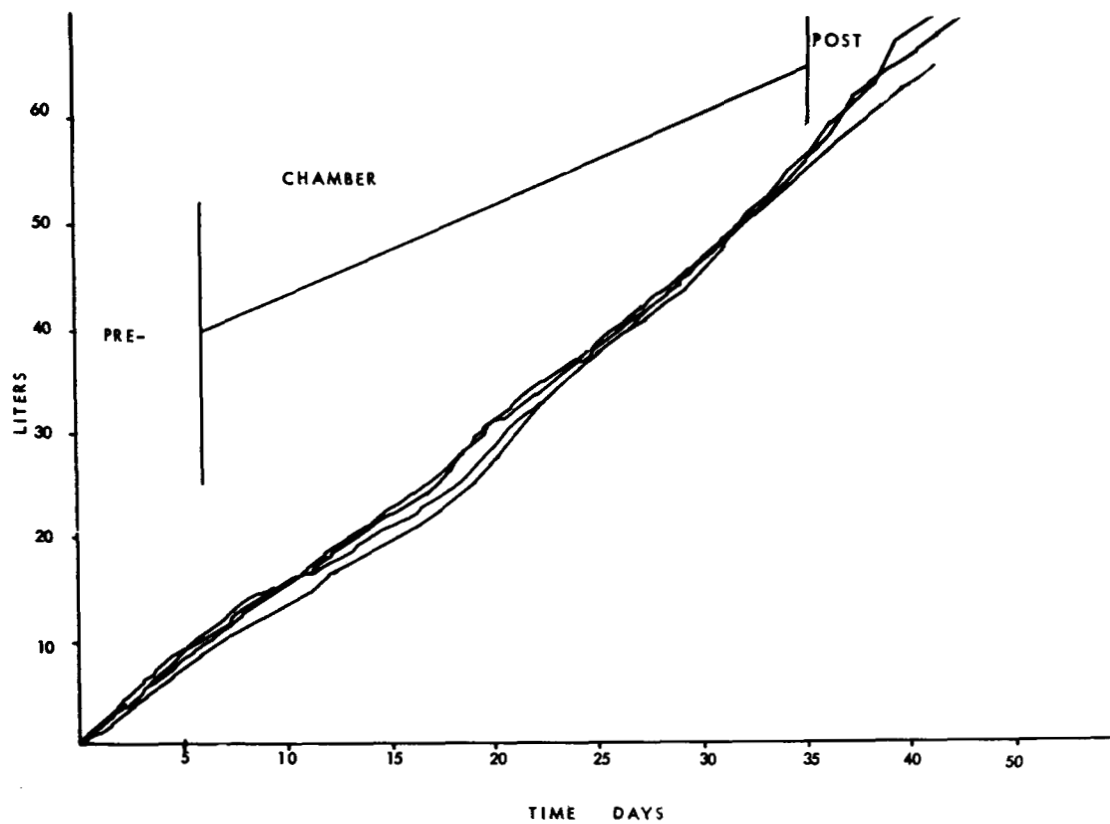


Figure 1. Cumulative urine excretion during control and chamber periods

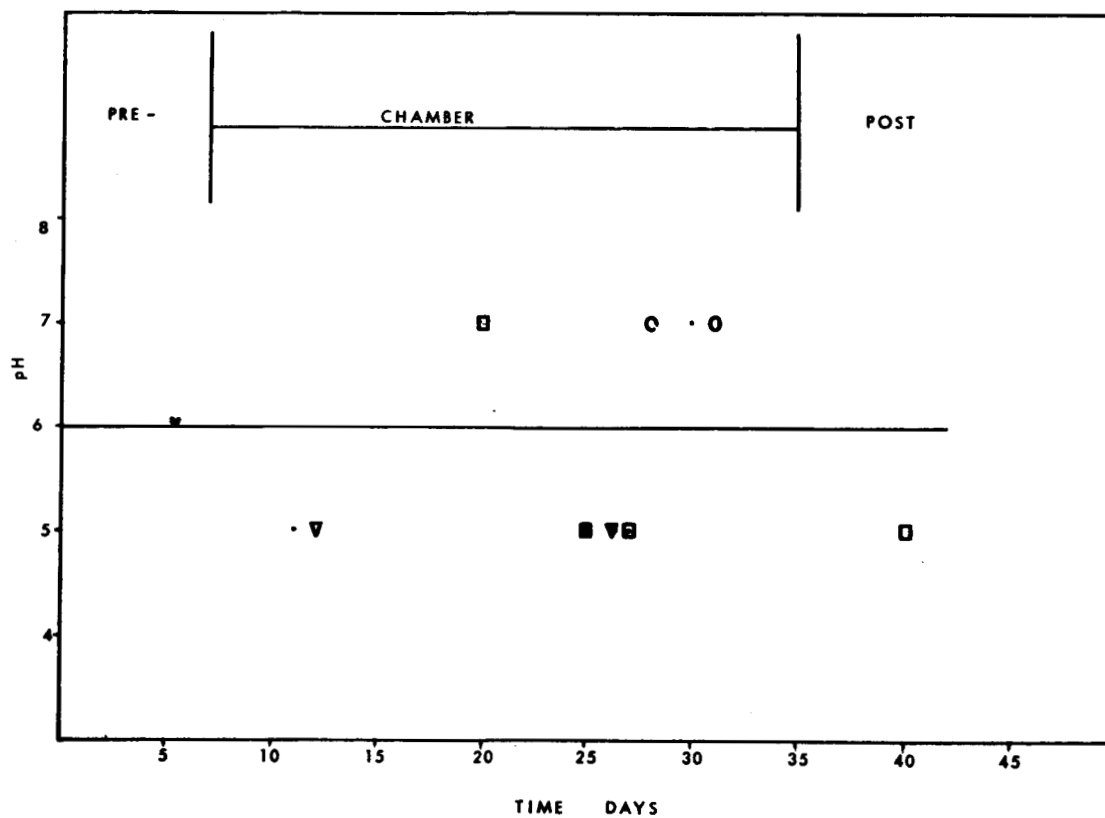


Figure 2. Urine pH during control and chamber periods. Symbols designate individual urine samples which had pH other than 6: subject 17 = •; subject 18 = ▽; subject 19 = □; subject 20 = ○.

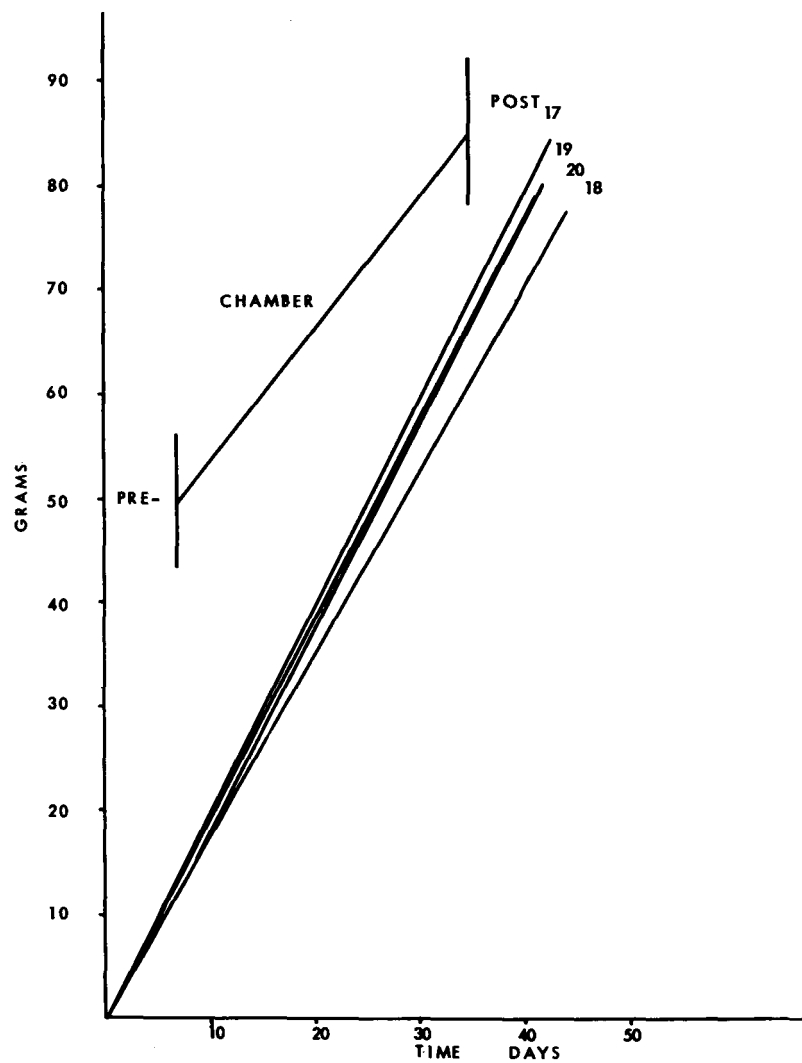


Figure 3. Cumulative urine excretion of creatinine during control and chamber periods.

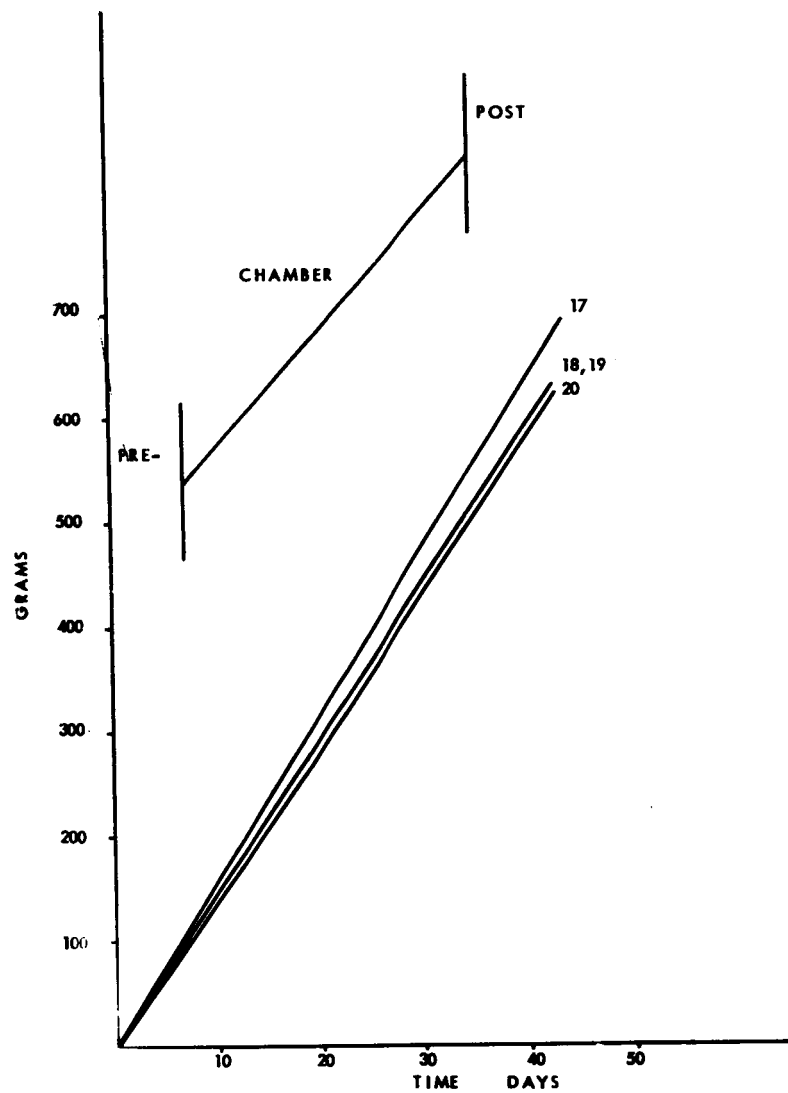


Figure 4. Cumulative urine excretion of nitrogen during control and chamber periods

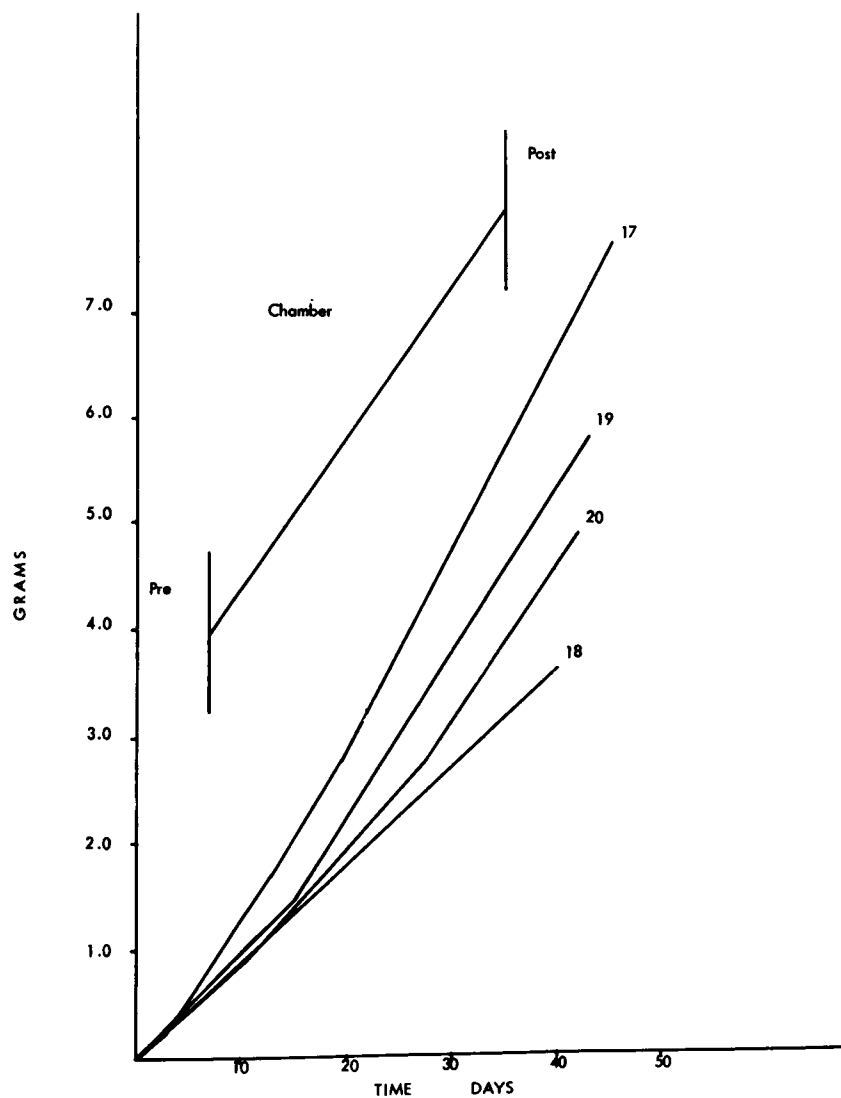


Figure 5. Cumulative urine excretion of calcium during control and chamber periods

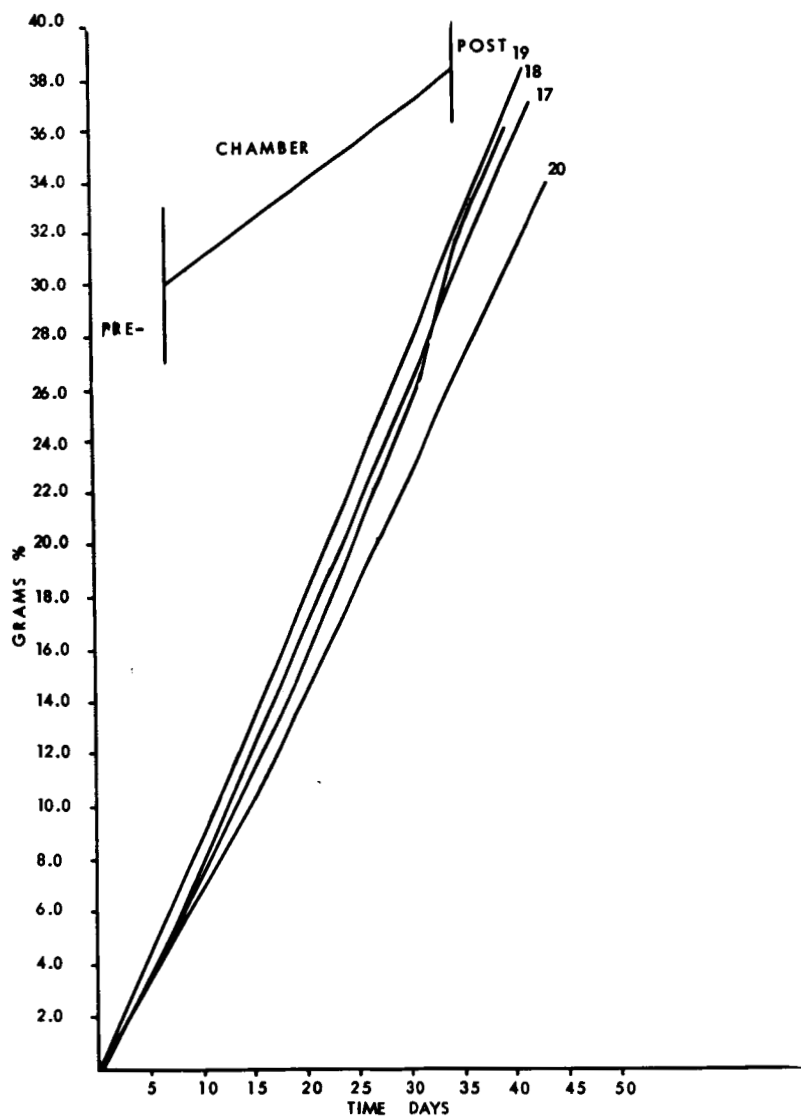


Figure 6. Cumulative urine excretion of phosphorus during control and chamber periods

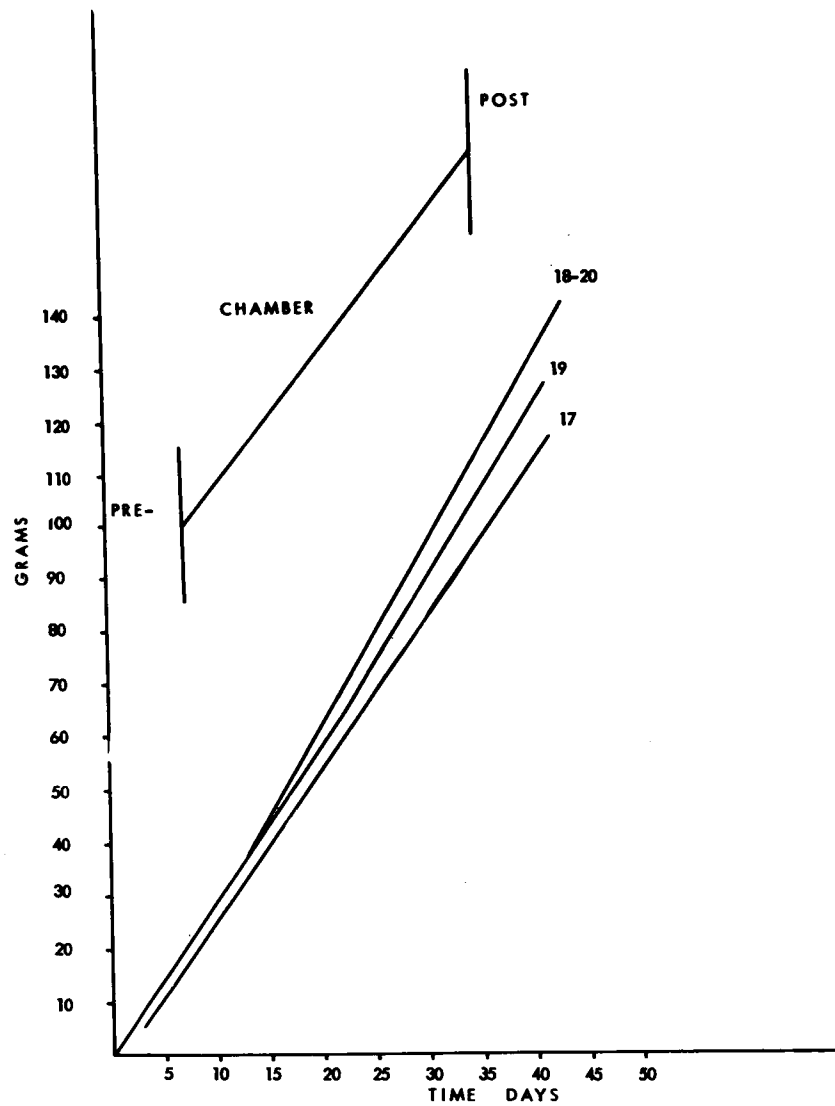


Figure 7. Cumulative urine excretion of sodium during control and chamber periods

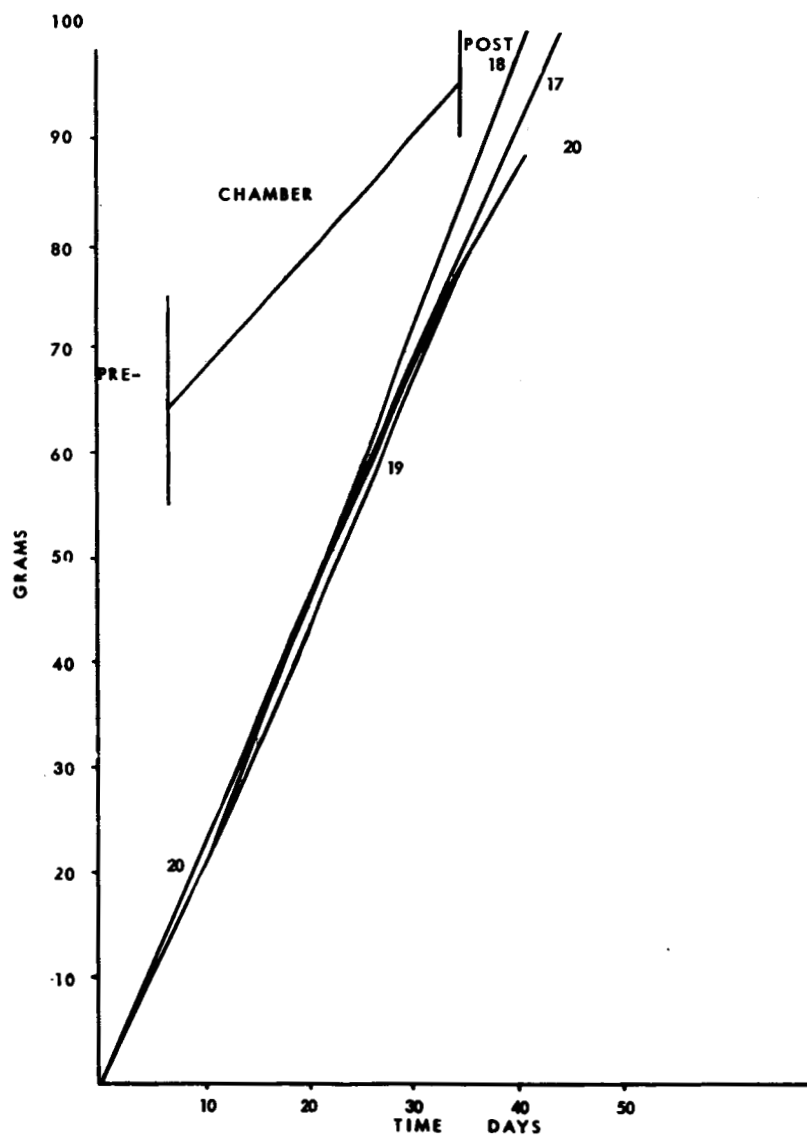


Figure 8. Cumulative urine excretion of potassium during control and chamber periods

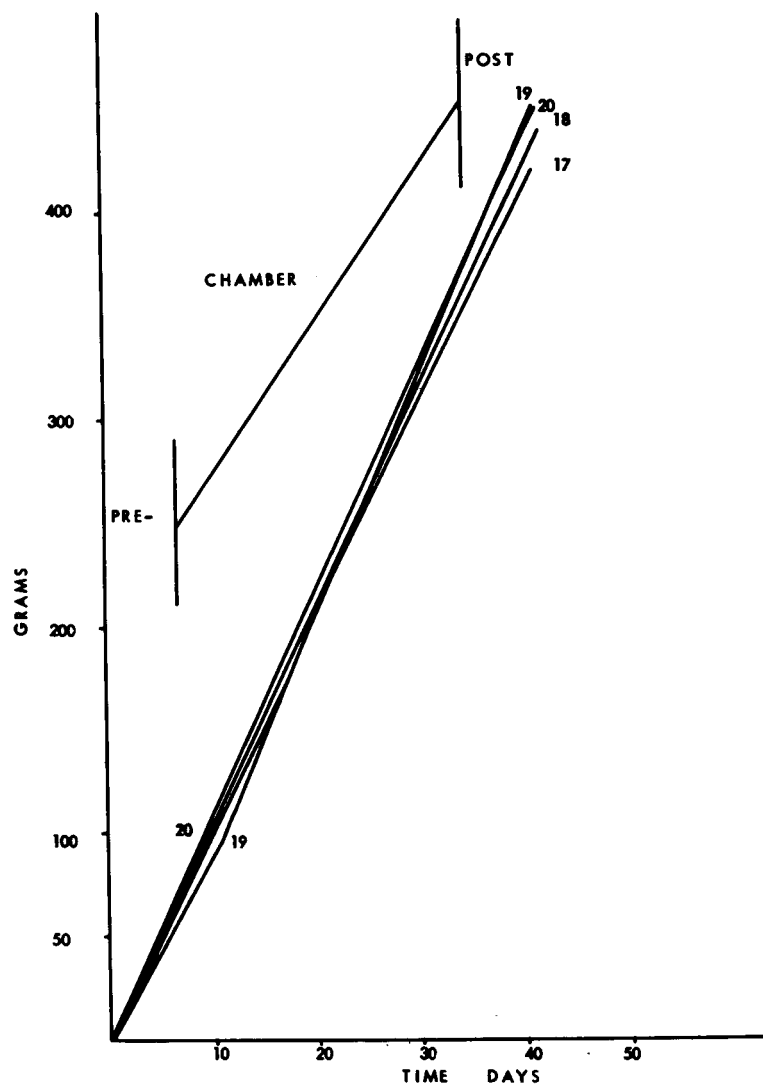


Figure 9. Cumulative urine excretion of chloride, expressed as sodium chloride, during control and chamber periods.

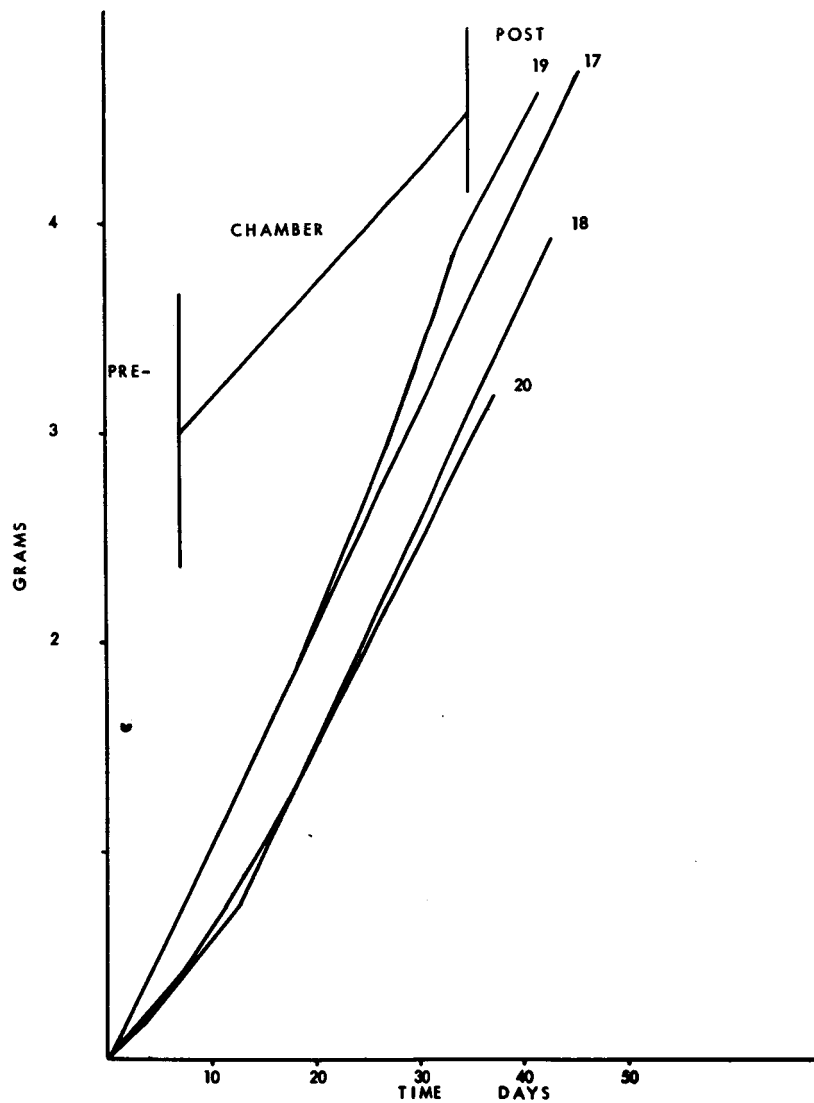


Figure 10. Cumulative urine excretion of magnesium during control and chamber periods.

SECTION IV

DISCUSSION

All four subjects completed the 6-week experimental study with no apparent adverse affects due to the stresses imposed. A successful confinement for 28 days within the Life Support Systems Evaluator constituted the major stress factor for this experiment in contrast to previous studies conducted solely within the controlled activity facility. The minor rash conditions in the groin area experienced by two subjects have been observed previously and were anticipated in view of the extended period of minimal personal hygiene. Otherwise, the subjects were, clinically, within the normal range reported for healthy individuals (29), and there were no significant effects associated with confinement in the LSSE. The narrow limits within which the clinical data varied is a reflection of the good dietary control effected during the study.

The subjects were in nitrogen and electrolyte balance. Nitrogen balance was good; a slight positive balance was found for all subjects for the entire experiment. Calcium balance was adequate with only one subject showing a negligible negative calcium balance of less than one-tenth of a gram. Apparent digestibilities of food constituents and electrolytes were in the ranges expected with monovalent cations found to show the highest apparent digestibility values of all components studied. High digestibilities of the major food stuffs and available energy indicated an adequate diet for the conditions and stresses of the study. In view of the fact that mammalian tissue does not contain the requisite enzyme for the degradation of cellulose, the occurrence of high apparent digestibilities for fiber appears to be enigmatic. There are two possible explanations. The fiber may be modified, structurally, during its passage through the stomach and intestines by changes in pH, to such an extent that its apparent disappearance may result from a change in its solubility in the chemical analysis. It is also possible that the microflora of the gut can digest the fiber and utilize it, or else the resultant glucose is absorbed in the intestine; thus, it is possible that cellulose is available for tissue utilization. The possibility that the microflora in the intestinal tract may modify cellulose should be given serious consideration. For example, *Bacteroides fragilis*, presumably the prominent bacterium in the lower intestinal tract of man (30), has been found to split dextran (31) and a strain of pleomorphic *Bacteroides* isolated from human feces produced heparinase and could dissimilate heparin and related mucopolysaccharides (32). Since the fiber content of the diet is so small with respect to total carbohydrate, it is not possible to determine this utilization from the energy balance.

Water balance data appear consistent with reported values (33) for individuals at ambient temperature and pressure and at low levels of activity.

Heart rate, blood pressure, and body temperature were within clinically normal ranges. No significant changes were observed among the separate experimental periods.

Body weight changes for the subjects for the separate experimental periods and over the entire experiment were minimal. The caloric content of the diet was adequate for the limited activity which prevailed and the minor weight losses experienced by three of the four subjects were adjustments to the diet from pre-experimental dietary regimens.

Although the acceptability rating for the combined diets over the entire study was "like moderately," certain discrepancies were noted. Foods containing gravy or cream sauce were rated unacceptable and certain food combinations were also rated as objectionable. The consumption of food at room temperature is believed to be the governing factor involved in the food acceptability ratings registered for this experiment. Adjustments of the dietary content, in direct relationship to the specific conditions to be imposed in future studies, will be required in order to increase the food acceptability ratings above those obtained during this study.

In summary, confinement in the LSSE did not affect the water, energy, or protein requirements of the four subjects. The diet was adequate and was utilized efficiently. There were no significant changes in the physiological, biochemical, nutritional, or clinical status of the subjects.

REFERENCES

1. Smith, K. J., Speckmann, E. W., George, M. E., Homer, G. M., and Dunco, D. W.: "Biochemical and physiological evaluation of human subjects wearing pressure suits under simulated aerospace conditions." AMRL-TR-65-147, Wright-Patterson Air Force Base, Ohio, October, 1965.
2. Katchman, B. J., Homer, G. M., and Dunco, D. P.: "The biochemical, physiological, and metabolic evaluation of human subjects wearing pressure suits and on a diet of precooked freeze dehydrated foods." AMRL-TR-66- , Wright-Patterson Air Force Base, Ohio,
3. Horwitz, W., (ed): Official Methods of Analysis of the Association of Official Agricultural Chemists. Ninth edition, A.O.A.C., Washington, D. C., 1960, p. 284.
4. Ibid, p. 12, 1960.
5. Ibid, p. 287, 1960.
6. Ibid, p. 288, 1960.
7. Ibid, p. 283, 1960.
8. Ibid, p. 76, 1960.
9. Ibid, Chapter 22.079, 1960.
10. Ntailianas, H. A., and Whitney, R. McL.: "Calcium as an indicator for the determination of total calcium and magnesium alone in the same aliquot of milk." J. Dairy Science, 47: 19-27, 1964.
11. Parks, P. S., and Dunn, D. E.: "Evaluation of the molybdovanadate photometric determination of phosphorus in mixed feeds and mineral supplements." J. Assoc. Offic. Agr. Chemists, 46: 836-838, 1963.
12. Oxygen Bomb Calorimetry and Combustion Methods, Manual 130, Parr Instrument Company, Moline, Illinois, 1960.
13. Gradwohl, R. B. H.: Clinical Laboratory Methods and Diagnosis, Fifth edition, The C. V. Mosby Co., St. Louis, Missouri, 1956, Vol. I, p. 574-654.
14. Hycel Cyanmethemoglobin Determinations. Revised edition, Hycel, Inc., Houston, Texas, 1962, p. 9.

15. McComb, R. B., and Yushok, W. D.: "Colorimetric estimation of D-glucose and 2-deoxy-D-glucose with glucose oxidase." J. Franklin Inst. 265: 417-422, 1958.
16. Coleman Ultramicro Analytical Program for the Determination of Creatinine in Plasma, T-159, Coleman Instruments, Inc., Maywood, Illinois, 1960.
17. Ibid, T-156, 1960.
18. Ibid, T-158, 1960.
19. O'Brien, D., and Ibbott, F. A.: Laboratory Manual of Pediatric Micro and Ultra-micro Biochemical Techniques. Harper and Row, New York, 1962, pp. 249-250.
20. New Flame Photometric Methods for Sodium and Potassium in Serum, Beckman Application Data Sheet, DV-12-B, Beckman Instrument Co., Fullerton, Calif. 1960.
21. Consolazio, C. F., Johnson, R. E., and Marek, E.: Metabolic Methods. The C. V. Mosby Co., St. Louis, Missouri, 1951, p. 82-83.
22. Refractometer, TS Meter, Model 10400, American Optical Company, Buffalo, New York.
23. Beckman Instruction Manual, Model 76, Expanded Scale pH Meter, Beckman Instrument Co., Fullerton, California, 1960.
24. Seiverd, C. E.: Chemistry for Medical Technologists. The C. V. Mosby Co., St. Louis, Missouri, 1958, p. 101.
25. Bowes, A. P., and Church, C. F.: Food Values of Portions Commonly Used, Ninth Edition. J. B. Lippincott Co., Philadelphia, Pennsylvania, 1963.
26. Cantarow, A., and Schepartz, B.: Biochemistry, Third Edition. W. B. Saunders Co., Philadelphia, Pennsylvania, 1962, p. 346.
27. Ibid, p. 664, 1962.
28. Consolazio, C. F., Johnson, R. E., and Pecora, L. J.: Physiological Measurements of Metabolic Functions in Man, McGraw-Hill Book Co., Inc., New York, 1963, p. 317.

29. Henry, R. J.: Clinical Chemistry, Harper and Row, New York, 1964.
30. Rosebury, T.: Microorganisms Indigenous to Man. McGraw-Hill Book Co., Inc., New York, 1962, p. 152.
31. Hehre, E. J., and Sery, T. W.: "Dextran-splitting anaerobic bacteria from the human intestine." J. Bacteriol. 63: 424-426, 1952.
32. Gesner, B. M., and Jenkin, C. R.: "Production of heparinase by Bacteroides." J. Bacteriol. 81: 595-604, 1961.
33. Cantarow, A., and Schepartz, B.: Biochemistry, Third Edition. W. B. Saunders Co., Philadelphia, Pennsylvania, 1962, p. 307.

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13. ABSTRACT A 6-week study with four college students as volunteer subjects was conducted for the purpose of evaluating the nutritional requirements of individuals undergoing stresses imposed by simulated aerospace conditions. A 4-day cycle diet of fresh foods was served at room temperature each day; it was comprised of 110 g of protein, 315 g of carbohydrate, 80 g of fat, and 2621 calories. All the clinical data were in the normal range and no significant differences were observed between control and confinement in the Life Support Systems Evaluator. Metabolic balances show excellent adjustment to the diet; all subjects were in positive nitrogen balance. Physiological measurements of heart rate, blood pressure, and oral temperature were in the normal ranges. Minimal body weight changes were observed indicating that the diet was adequate. The diet was only moderately acceptable because all food was served at room temperature; gravy and cream sauces were rated least acceptable for this reason.			

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Diets, space Organoleptic acceptability Nutritional balance study Metabolism Confinement						

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